REMEDIAL INVESTIGATION REPORT
PATRICK BAYOU SUPERFUND SITE
DEER PARK, TEXAS

Prepared for

Patrick Bayou Joint Defense Group

U.S. Environmental Protection Agency

Prepared by

Anchor QEA, LLC

614 Magnolia Avenue

Ocean Springs, Mississippi 39564

September 2013

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LIST OF ACRONYMS AND ABBREVIATIONS

μg/kg	micrograms per kilogram
μg/L	micrograms per liter
μm	micrometer
Anchor QEA	Anchor QEA, LLC
AOC	Administrative Order on Consent
APAR	Affected Property Assessment Report
ARAR	Applicable or Relevant and Appropriate Requirement
ATSDR	Agency for Toxic Substances and Disease Registry
AVS	acid volatile sulfides
BEHP	bis(2-ethylhexyl) phthalate
BERA	Baseline Ecological Risk Assessment
bgs	below ground surface
BHHRA	Baseline Human Health Risk Assessment
CCA	Chemical Correspondence Analysis
cfs	cubic feet per second
cm	centimeter
CML	Chemical Mass Loading
COC	chemical of concern
COI	chemical of interest
COPC	contaminant of potential concern
CSM	conceptual site model
DCA	decision consequence analysis
DCP	data collection platform
DNAPL	dense nonaqueous-phase liquid
ERA	Ecological Risk Assessment
FS	Feasibility Study
g/cm^3	grams per cubic centimeter
GBA	Gahagan and Bryant Associates, Inc.
H-GAC	Houston-Galveston Area Council
HI	hazard index
HpCDD	heptachlorodibenzo-p-dioxin

HQ	hazard quotient
HSC	Houston Ship Channel
HxCDD	hexachlorodibenzo-p-dioxin
IC	indicator chemical
JDG	Patrick Bayou Joint Defense Group
LiDAR	light detection and ranging
LNAPL	light nonaqueous-phase liquid
LOE	line of evidence
Lubrizol	The Lubrizol Corporation
mg/kg	milligrams per kilogram
mg/L	milligrams per liter
MNR	monitored natural recovery
MSL	mean sea level
NAPL	nonaqueous-phase liquid
NAVD88	North American Vertical Datum of 1988
ng/kg	nanograms per kilogram
NOAA	National Oceanic and Atmospheric Administration
NPL	National Priorities List
NSR	net sedimentation rate
OCDD	octachlorodibenzo-p-dioxin
OCDF	octachlorodibenzofuran
Oxy	Occidental Chemical Company
OxyVinyls	OxyVinyls, LP
PAH	polycyclic aromatic hydrocarbon
PCB	polychlorinated biphenyl
PCDD	polychlorinated dibenzodioxin
PCDF	polychlorinated dibenzofuran
PCOPC	preliminary contaminants of potential concern
PeCDF	pentachlorodibenzofuran
PEL-Q	Probable Effects Level-Quotient
PMZ	Plume Management Zone
POE	point of exposure
PRAO	preliminary remedial action objective

PSCR	Preliminary Site Characterization Report
PVC	polyvinyl chloride
RAO	Remedial Action Objectives
RI	Remedial Investigation
RME	reasonable maximum exposure
SAP	Sampling and Analysis Plan
SAT	Spatial Analysis of Toxicity
SEM	simultaneously extracted metals
SH	State Highway
Shell	Shell Oil Company
Site	Patrick Bayou Superfund Site
SOW	Statement of Work
STM	sediment transport model
SVOC	semi-volatile organic compound
TBC	to be considered
TCEQ	Texas Commission on Environmental Quality
TDH	The Texas Department of Health
TDSHS	Texas Department of State Health Services
TEF	Toxicity Equivalency Factor
TEQ	Toxic Equivalents
TMDL	total maximum daily load
TNRCC	Texas Natural Resource and Conservation Commission
TOC	total organic carbon
TRRP	Texas Risk Reduction Program
TSS	total suspended solid
USEPA	U.S. Environmental Protection Agency
USGS	U.S. Geological Survey
VCM	vinyl chloride monomer
VCP	Voluntary Cleanup Program
VOC	volatile organic compound
WBZ	water-bearing zone
WMA	waste management area
WOE	weight-of-evidence

WSE	water surface elevation
WWTP	Wastewater Treatment Plant

EXECUTIVE SUMMARY

Under the direction of the U.S. Environmental Protection Agency (USEPA), the Patrick Bayou Joint Defense Group (JDG) is conducting a Remedial Investigation (RI) and Feasibility Study (FS) at the Patrick Bayou Superfund Site (Site) in Deer Park, Texas. The work is being conducted under an Administrative Order on Consent (AOC) and Settlement Agreement dated January 31, 2006. This RI Report describes field investigations conducted at the Site, as described in prior USEPA-approved work plans, along with results and analysis of the collected data necessary and consistent with the requirements of the Statement of Work (SOW) attached to the AOC.

The purpose of an RI is to collect, develop, and evaluate sufficient information to determine if cleanup actions at the Site are necessary, to establish Remedial Action Objectives (RAO) for the Site, if necessary, and to support the evaluation of remedial alternatives in the FS and selection of a final remedy.

Site Description

Patrick Bayou is a tributary of the Houston Ship Channel (HSC) in Harris County, Texas, that discharges at the south shore of the HSC approximately 2.3 miles upstream of the HSC confluence with the San Jacinto River. The Site originates north of State Highway (SH) 225 at the downstream terminus of a set of box culverts that lie underneath the highway and flows north approximately 10,200 feet to the HSC. The Site itself is bordered by industrial facilities owned by Shell Oil Company (Shell), The Lubrizol Corporation (Lubrizol), and Occidental Chemical Corporation (Oxy).

The drainage upstream of the Site originates in the City of Deer Park and consists of trapezoidal, concrete-lined ditches that transition into box culverts underneath SH 225. The City of Deer Park Wastewater Treatment Plant provides a baseflow discharge into the Site even when there is minimal flow from rain events or other sources within the City of Deer Park. A tributary of the Site, referred to as the East Fork, joins the Site approximately 6500 feet upstream of the HSC, and drains an area of slightly more than 300-acres. Rohm and Haas Company and Praxair, Inc., have facilities upstream and adjacent to the East Fork Tributary.

Environmental Datasets

Data included in the project database for use in the RI/FS are a combination of historical data collected at or in the immediate vicinity of the Site boundaries prior to the execution of the AOC, third party data that were not specifically collected in support of the AOC requirements but were deemed appropriate to support the objectives of the RI/FS, and data collected specifically to support the RI/FS.

Historical and third party investigation events and samples for surface water, bulk sediment, and biological data include: 1) bulk sediment chemistry data generated for the Texas Natural Resource and Conservation Commission (TNRCC) Hazard Ranking System study (TNRCC 2001); 2) surface water chemistry data generated by Texas Commission on Environmental Quality (TCEQ) from 1996 to present; 3) tissue data generated by TCEQ (2010a, 2010b) and TDSHS (2001, 2005); and 4) benthic community surveys and sediment bioassay tests performed for the sediment toxicity assessments by Parsons et al. (2002, 2004), and routine and special monitoring studies performed by TCEQ (Broach 2008).

Investigation activities for Site media in support of the RI/FS included sampling and analysis of bulk sediment, suspended sediment, porewater, surface water, and biota (i.e., both whole body and edible fish and shellfish tissue), as well as, physical and geotechnical investigations. Sediment samples were collected in a manner to characterize the Site both vertically and laterally. Sediment and surface water samples were also collected adjacent to but outside of the Site boundary.

Potential groundwater impacts to the Site have been evaluated through numerous independent investigations conducted at adjacent properties (Shell, Lubrizol, and Oxy) over the last several years. TCEQ-approved corrective actions are underway at each facility that prevent unacceptable impacts to the Site, where necessary.

Indicator Chemicals

To facilitate a clear and practical presentation of the nature and distribution of chemcials of concern (COC) at the Site for the RI, an indicator chemical (IC) list was identified from a broad list of COCs to represent the nature and extent of the range of contaminants in Site media. The ICs selected for the RI are media-specific and are based on the results of the baseline human health and ecological risk assessments (Anchor QEA 2012a, 2013a) and to a lesser extent on non-risk-based factors. Polychlorinated biphenyls (PCBs), lead, total polycyclic aromatic hydrocarbons (PAHs), and bis(2-ethylhexyl) phthalate (BEHP) were identified as ICs for sediment, porewater, and suspended sediment. PCBs are the only IC identified for surface water. PCBs in whole body and edible tissue are considered the primary IC for biota. There are no groundwater ICs.

Source Characterization

The Site and the surrounding area have been used for industrial and commercial operations for nearly a century. Upstream areas have become heavily urbanized as the industrial and commercial nature of the area expanded. During this time, chemicals associated with those practices were released from various sources through migration pathways to the Site sediments some of which may pose risk to receptors. Activities and processes that may have led to either point or nonpoint releases to the Site include petroleum refining, storage, and distribution; chemical manufacturing and formulation; urban development and land use; agricultural applications; industrial shipping and use of the HSC; dredging of the HSC; electrical substation operation and maintenance; and sewage treatment. Potential source pathways identified in the RI include direct discharge, groundwater discharge, spills, bank erosion, atmospheric deposition, interaction with the HSC (i.e., tidally-influenced downstream sources), and upstream sources. Other than continuing potential impacts associated with urban runoff and interaction with the HSC, the bulk of the loading of ICs within the Site appears to be associated with historical releases.

The vertical distribution of ICs in Site sediments is consistent with historical releases. An increasing gradient in the concentration of ICs with depth is apparent at locations with accumulated sediments. The higher concentration of ICs at depth is indicative of historical releases. As a whole, the Site is net depositional over annual time scales, indicating that natural recovery of the sediment is an ongoing, active process at the Site. Hydrodynamic and sediment transport modeling results for the Site indicate that for about 70 percent of the Site, the concentration of an IC in the mixing zone layer will decrease by one-half of its current concentration in less than 10 years in areas assuming “clean” sediment input.

Chemical Fate and Transport

External loads of chemicals can enter the Site as point sources (e.g., tributaries or outfalls), distributed sources (e.g., atmospheric deposition, surface runoff, tidal exchange). Hydrodynamic processes such as freshwater flow and tidal circulation cause chemicals to be transported within the water column in the direction of the currents. Other fate processes that occur in the water column include partitioning between dissolved and particulate phases and degradation reactions (for some chemicals and under certain conditions). Chemicals in the water column can be lost to the atmosphere via volatilization, depending on their characteristics. Chemicals are also exchanged with the underlying sediment bed via the processes of deposition and resuspension of sediments and associated particulate-phase contaminants, and by porewater exchange flux. A number of fate and transport processes also occur within the sediment bed, including mixing (i.e., bioturbation) within the surficial sediments, vertical transport/exchange within the porewater, as well as partitioning and biodegradation. In a net depositional environment, there is a net effective transfer of contaminants from the surficial layers to the deeper layers of the bed (i.e., burial).

There are several key chemical fate processes affecting PCBs (the driving IC for the Site) and similar sorptive compounds within the aquatic environment of the Site. They include:

- Sediment-water interactions – Because of the hydrophobic nature of PCBs, they preferentially bind to particulate matter. The sediment bed, therefore, serves as a net sink, adsorbing PCBs. To the extent that PCBs may have accumulated within the bed over time (e.g., if there were historical releases and subsequent transport), they can act as a source to the water column, and chemicals being transported in the water column can likewise deposit on the bed. The fluxes between the bed and water column are driven largely by sediment deposition and erosion processes, especially during episodic events such as floods and hurricanes. Deposition also provides a mechanism for natural recovery if contaminant concentrations of particles in the water column are lower than those at the bed surface. Thus, within-bed dynamics (e.g., transfers between surface and deeper layers of the bed) are also important.
- Partitioning and dissolved phase flux – The distribution of PCBs between the particulate and dissolved phases within the water column and bed sediments are determined by their partitioning behavior (as quantified by the partitioning

coefficient). Because they are highly hydrophobic, PCBs will primarily be present in particulate form, which means that their fate is largely determined by sediment transport processes. However, in areas where PCBs have accumulated within the surface layer of the sediment bed, partitioning will result in porewater concentrations that can be much greater than those in the overlying water column. Such a concentration gradient, through the process of surface exchange flux (due to diffusion, bioturbation, and tidal pumping), results in a transfer of dissolved-phase mass to the water column that can affect concentrations in the Site under low flow conditions.

- Transport in the water column – PCBs that are present in the water column, in both dissolved and particulate phases, are transported with the currents, which are affected by freshwater flow in addition to more complex circulation patterns associated with the tides.

Because sediment transport processes have an effect on the fate and transport of suspended and deposited particles, a numerical model was developed as a quantitative tool for evaluation of short-term and long-term sediment transport activities at the Site as part of the RI. This model is the basis for developing a tool to evaluate the chemical fate and transport of PCBs at the Site. The chemical fate and transport model will be further refined and utilized in the Site FS to evaluate baseline conditions and the effect of potential remedial alternatives on water quality issues associated with PCBs in sediments at the Site.

Baseline Risk Assessment

A baseline human health risk assessment (BHHRA) and a baseline ecological risk assessment (BERA) for the Site were performed as part of the RI.

The BHHRA conceptual site model (CSM) was developed for the Site to illustrate known and suspected sources of chemical contamination, types of chemicals and affected media, known and potential routes of migration, and known or potential human receptors. The CSM concluded that the on-site potentially exposed populations were restricted to on-site utility and construction workers. The off-site subpopulations of concern that were evaluated are fishermen and their families who may catch and consume fish or shellfish that have been exposed to Site contaminants.

The following conclusions were made in the USEPA-approved BHHRA:

- No unacceptable excess lifetime cancer risk or non-cancer hazards exist for on-site workers that may come into contact with or incidentally ingest Site sediments as a result of maintenance or construction activities at the Site. No COCs were identified for this receptor; thus, risk management recommendations are not warranted.
- Spatial and statistical analysis of fish and shellfish tissue data did not indicate an incremental contribution of PCBs and polychlorinated dibenzodioxins and polychlorinated dibenzofurans (PCDDs/PCDFs) from the Site to the fish and shellfish at the point of exposure (POE) in the HSC that may be caught and consumed by fishermen and their families. Thus, this exposure pathway, while potentially complete, does not contribute significantly to incremental cancer risks or non-cancer hazards for these receptors. Thus, risks for this receptor were not quantitatively evaluated for this pathway or receptor and no risk management recommendations were identified.

The BERA CSM illustrates known and suspected sources of chemical contamination, types of chemicals and affected media, known and potential routes of migration, and known or potential ecological receptors. Complete and potentially significant exposure pathways were identified for the following ecological receptors:

- Benthic invertebrate community
- Fish community
- Sediment-probing birds and omnivorous/herbivorous birds – spotted sandpiper
- Carnivorous wading birds – composite avian receptor
- Piscivorous birds – belted kingfisher
- Omnivorous/herbivorous mammals – raccoon

The exposure pathways for these receptors include a combination of direct contact with sediment, sediment ingestion, biota ingestion, and contact with porewater and surface water. The following conclusions were made in USEPA-approved BERA:

- PCB toxic equivalents (TEQs) hazard quotients (HQs) for the sediment-probing and piscivorous bird receptor groups are equal to 1.0 and 1.7 for spotted sandpiper and belted kingfisher, respectively. However, uncertainty analyses indicate that HQs for these COPC-receptor pairs may be above or below the threshold of concern (HQ = 1.0) depending on the assumptions used to characterize risk. Thus, within the ranges of exposure and effects variables evaluated, risks may or may not exceed a threshold of concern for individuals exposed to PCBs in Site media.

- Risks to fish populations at the Site are negligible and no risk management for this receptor group is necessary.
- Using a weight-of-evidence (WOE) approach, areas of probable benthic risk have been identified. Although a quantitative risk characterization for the benthic community could not be performed within the acceptable range of uncertainty in the BERA, it is apparent that probable risks to the benthic community are likely associated with PCBs in bulk sediment. Ecological risk occurs along a continuum and there is not a quantifiable bright line for those risks. Remedial alternatives will be evaluated in the FS that lower the overall Site and sub-area risk for areas that are characterized as indeterminate and probable risks.

Preliminary Remedial Action Objectives

The urban and highly industrial nature of the Site and the long-term commitment to these uses must be considered in selection of an overall management goal. Given the physical setting of the Site, the overall preliminary remedial action objective (PRAO) is to protect populations of sensitive ecological receptors that may feed at the Site and prevent measurable degradation of downstream resources from Site sediment transport. Additionally, the protection of benthic invertebrates from sediment toxicity associated with PCBs and secondary COCs (PAHs, lead, and BEHP) was identified as a primary PRAO. The BERA did not contain specific risk management recommendations due to the uncertainty associated with risks to benthic invertebrates. However, risk management for ecological receptors will be considered within the overall context of other risk management considerations (e.g., water quality standards) during the FS. The physical conditions of the Site, including natural variations in stream flow, bed configuration and substrate, hydraulic gradient, grain size, water temperature and salinity, as well as, the industrial nature of the land use will prevent restoration of the Site to a uniform measure of ecological function. Because of these limitations, the ultimate focus of the RI/FS is to develop a strategy for producing beneficial changes by identifying and managing the controllable stressors on the Site ecosystem.

There are no known active sources of chemicals from Site-adjacent industrial facilities (e.g., Shell, Oxy, and Lubrizol) to the Site surface water or sediments from air, groundwater, surface water, soil, active outfalls, or spills. However, there is likely ongoing loading of COCs and other chemicals to the Site sediments and surface water from ongoing urban runoff drainage, the Waste Water Treatment Plant at the City of Deer Park, and air deposition. Based on this source assessment and the available RI/FS data for sediments and surface water, any potential remedial actions at the Site should focused on controlling direct sediment contact, sediment/surface water interaction, and surface water exposure pathways for ecological receptors. Addressing these pathways would also address potential water quality concerns associated with PCBs.

1 INTRODUCTION

Under the direction of the U.S. Environmental Protection Agency (USEPA), the Patrick Bayou Joint Defense Group (JDG)[1] is conducting a Remedial Investigation (RI) and Feasibility Study (FS) at the Patrick Bayou Superfund Site (Site) in Deer Park, Texas. The work is being conducted under an Administrative Order on Consent (AOC) and Settlement Agreement dated January 31, 2006. This RI Report describes field investigations conducted at the Site, as described in prior USEPA-approved work plans, along with results and analysis of the collected data necessary and consistent with the requirements of the Statement of Work (SOW) attached to the AOC. Also included are results of the associated risk assessments required by the AOC. This RI Report was prepared by Anchor QEA, LLC (Anchor QEA), under the direction of the USEPA and JDG.

The purpose of an RI is to collect, develop, and evaluate sufficient information to determine if cleanup actions at the Site are necessary, to establish Remedial Action Objectives (RAO) for the Site, if necessary, and to support the evaluation of remedial alternatives in the FS and selection of a final remedy. Because the Site is comprised of exclusively aquatic lands, the media of concern are primarily surface water and sediment[2]. In addition to the RI field investigations conducted under USEPA oversight, the scope and results of previous environmental investigations performed at the Site under the oversight of the Texas Commission on Environmental Quality (TCEQ[3]) and other agencies and entities are included, as appropriate, to provide a comprehensive summary of Site conditions.

1.1 Purpose of Report

The purpose of this RI Report is to compile, develop, and evaluate the comprehensive sampling and analysis performed at the Site to describe the environmental setting, identify sources of contamination, characterize the nature and extent of contamination, evaluate the chemical fate and transport of contaminants at the Site, describe potential ecological and human health risk at the Site, and establish RAOs. Analysis of the data focuses on

[1] The Patrick Bayou JDG includes the Respondents to the AOC and Settlement Agreement dated January 31, 2006 for the RI/FS. The JDG includes The Lubrizol Corporation, Occidental Chemical Corporation, and Shell Oil Company, on behalf of Deer Park Refining Limited Partnership and Shell Chemical, LLP.

[2] Tissue sampling and analysis was also performed as part of the baseline risk assessments.

[3] Formerly the Texas Natural Resource and Conservation Commission.

refinement of the conceptual site models (CSM) for the Site. Potential remedial technologies for the Site were screened during the *Remedial Alternatives Technology Screening* (Anchor QEA 2013b) and will serve as a basis for the FS Report. The forthcoming FS Report will be prepared to document the development and detailed analysis of remedial alternatives and to provide a basis for remedy selection by USEPA.

This RI Report complements previously submitted, and agency approved, documents related to the RI process at the Site, notably the *Preliminary Site Characterization Report* (PSCR; Anchor 2006a), *Remedial Investigation Work Plan* (RI Work Plan; Anchor 2007a), *Baseline Human Health Risk Assessment Report* (BHHRA Report; Anchor QEA 2012c), and *Baseline Ecological Risk Assessment Report* (BERA Report; Anchor QEA 2013a). For clarity and where prudent, the information provided in those documents and others is incorporated by reference and not repeated herein.

1.2 Regulatory Basis

Patrick Bayou was proposed for addition to the National Priorities List (NPL; 66 FR 32287) on June 14, 2001, pursuant to the Hazard Ranking System, which USEPA promulgated as Appendix A of the National Contingency Plan (40 CFR part 300). The Site was finalized on the NPL on September 5, 2002 (67 FR 56747). The RI/FS for the Site is required in the AOC and Settlement Agreement with the USEPA dated January 31, 2006, and in accordance with the SOW attached to the AOC.

This RI Report was prepared to satisfy the requirements of Task 3 in the SOW. The report was prepared in accordance with *Interim Final Guidance for Conducting Remedial Investigations and Feasibility Studies Under CERCLA* (USEPA 1988) and the USEPA-approved RI Work Plan (Anchor 2007a), which provides a general framework for Site investigations.

1.2.1 Adaptive Management Framework

As approved by USEPA (June 7, 2006), work at the Site has been performed using an adaptive management framework for contaminated sediment sites (USEPA 2005), whereby work is completed, results are evaluated, the understanding of the Site is updated, and future work plans are developed and revised as appropriate. Consistent with this approach, Site investigations were performed and summarized as a series of data reports subsequent to each investigation. In several cases, a full evaluation of selected data was completed to advance the CSM. Finally, several risk assessment reports, including the baseline risk assessments, were submitted to USEPA for review and approval prior to the RI Report. Results and analyses of these reports are incorporated herein.

1.3 Site Description

Patrick Bayou is a tributary of the Houston Ship Channel (HSC) in Harris County, Texas, (Figure 1-1) that discharges at the south shore of the HSC approximately 2.3 miles upstream of the HSC confluence with the San Jacinto River. The Site itself and its physical features are described in more detail in the PSCR (Anchor 2006a); a brief summary is provided below.

The Site originates north of State Highway (SH) 225 at the downstream terminus of a set of box culverts that lie underneath the highway and flows north approximately 10,200 feet to the HSC (Figure 1-2)[4]. The Site itself is bordered by three separate facilities owned by Shell Oil Company (Shell), The Lubrizol Corporation (Lubrizol), and Occidental Chemical Corporation (Oxy).

The drainage upstream of the Site originates in the City of Deer Park and consists of trapezoidal, concrete-lined ditches that transition into box culverts underneath SH 225. The City of Deer Park Wastewater Treatment Plant (WWTP) discharges effluent into these ditches through a drainage that is adjacent, parallel to SH 225, and just upstream of the box culverts. This WWTP provides a baseflow discharge into the Site even when there is minimal flow from rain events or other sources within the City of Deer Park. The box culverts underneath SH 225 emerge into a narrow channel with steep side slopes that are lined with fabric formed concrete revetments (i.e., Fabriform®). This section of the Site has been referred to as the gunite-lined portion of the Site in the past. Station PB-102 represents the upstream boundary of the Site and coincides with the upstream tidal boundary of the

[4] A station numbering system was developed for the Site for consistency and ease of reference throughout this document and associated figures. In this system, station identifiers are named so the last three numbers in the identifier reflect the station's distance from the mouth of Patrick Bayou in hundreds of feet. For example, the upstream boundary of the Site is at Station PB-102 (10,200 feet from the HSC).

main channel of Patrick Bayou. This portion of the channel has a compacted earthen and rubble/debris bottom with Fabriform®/gunite sides and extends approximately 2,200 feet downstream to Station PB-080 where it transitions to a more natural and less confined channel for the remaining downstream length of the Site[5]. Moving downstream from Station PB-080, the channel is bordered by a combination of natural and armored (primarily concrete riprap) banks. A tributary of the Site, referred to as the East Fork, joins the Site near PB-065 of the main channel (Figure 1-2). The East Fork is a small stream, approximately 5,500 feet long, that flows in a northwesterly direction. The East Fork varies between 1 to 10 feet in width and 1 to 3 feet in depth. Most of its length has naturally sloping, shallow banks. The bottom substrate is natural, unconsolidated material. The East Fork drains an area of slightly more than 300 acres. Rohm and Haas Company and Praxair, Inc., have manufacturing operations upstream and adjacent to the East Fork Tributary.

The Site widens to approximately 330 feet at the confluence with the East Fork Tributary and the main channel ranges between 40 to 480 feet wide for the next 2,500 feet (between PB-065 and PB-040). Narrower parts of the Site are associated with structures (bridges) and channel modifications. Two small islands, approximately 0.35 acres in size, are located near the center of the channel before the Site makes an easterly turn between PB-020 and PB-015. Approximately 340 feet downstream of the islands, an elevated pipeline and bridge cross the Site to a loading terminal located on the HSC. The Site discharges into the HSC approximately 1,000 feet from the pipeline crossing and bridge. The width of this lower portion varies between 300 and 500 feet, reaching its widest point where it joins the HSC.

1.4 Site History

Patrick Bayou was named for the original 1838 grantee for the land around the bayou, George M. Patrick (Texas Land Grant Office 2013). The surrounding settlement, Deer Park, was named for a privately owned park for deer that inhabited the area. Deer Park was developed in 1892 by land promoters hoping for Midwestern farmer settlement (Laird 2008), and a railroad station was soon established nearby. The new community grew, and later experienced a great expansion in the 1940s, when Deer Park became the site for various

[5] This section of the main channel (PB-102 to PB-080) is generally referred to the 'gunite-lined channel' for ease of reference.

refineries and toluol (toluene) plants (Kleiner 2013). The City of Deer Park was incorporated on December 12, 1948. Today, Deer Park has approximately 10,000 homes, 30,000 residents, numerous smaller light industrial and commercial businesses, and several major industrial facilities (City of Deer Park 2013).

The Site is currently bounded by the facilities of Shell, Lubrizol, and Oxy. Other nearby facilities include Praxair, Inc., Rohm and Haas Texas, Inc., and the City of Deer Park WWTP. A brief history of these facilities is provided below.

1.4.1 Shell Deer Park

Shell Deer Park is a joint oil refinery and chemical manufacturing site. Shell Deer Park Refining Company operates the refinery while chemicals are made by Shell Chemical, LP. Shell's refinery began operation in 1929 and was the first manufacturer to be based in Deer Park. Currently, the refinery has a crude oil capacity of 340,000 barrels per day (Shell 2013a). Chemical manufacturing began in the 1940s, during which time the operation produced ten million gallons of toluene annually (Kleiner 2013). In 1988, the company transferred its vinyl chloride monomer (VCM) plant to Oxy, and in 1999, Shell Deer Park began operation of a new phenol/acetone plant. In 2000, the company divested its resins plant to Hexion Specialty Chemicals (now Momentive Specialty Chemicals). Today, the products manufactured include ethylene, propylene, butylene, isoprene, butadiene, piperylene, dicyclopentadiene, benzene, toluene, xylenes, phenol, acetone, and cumene (Shell 2013b).

1.4.2 OxyVinyls, LP

OxyVinyls, LP, (OxyVinyls) is a subsidiary of Oxy. Their Deer Park facility began operations in 1948. The facility has been used to produce chlorine, polyvinyl chloride (PVC), 1,2-dichloroethene, tetrachloroethylene, trichloroethylene, (VCM) hydrochloric acid, sodium methylate, ammonia, acetylene, chlorowax, anhydrous caustic, and anhydrous potassium hydroxide (i.e., caustic potash). The Deer Park facility currently produces PVC and caustic potash (Oxy 2013). Formerly, the facility included a chloralkali manufacturing plant, which was closed in the early 2000s.

1.4.3 The Lubrizol Corporation

Lubrizol manufactures lubricant materials for the global transportation, industrial, and consumer markets, as well as performance coatings, personal and home care products, and life science and engineered polymers. The Lubrizol Deer Park facility has been producing lubricant additives since 1951 and is Lubrizol's largest plant by volume. Initially, the plant produced oxidation inhibitors and detergents for lubricants. Between 1951 and 1968 dispersants, high pressure wear additives, and poly isobutylene were added to the product lines. Primary production processes include low temperature, solvent-based batch processing and blending to produce additives in the product line.

1.4.4 Praxair, Inc.

Praxair, Inc., manufactures atmospheric and process gases and high performance surface coatings, and supplies refineries and petrochemical plants along the Texas Gulf Coast. The Deer Park plant operated from the 1980s until 2008, when the gaseous oxygen operation was closed and moved to Texas City, Texas (Praxair 2013).

1.4.5 Rohm and Haas Texas, Inc.

The Rohm and Haas Texas, Inc., Deer Park facility was constructed in 1947, and began large-scale production of acrylate monomers, the raw materials of its acrylic business. The plant currently produces specialty chemicals, including methyl methacrylate, acrylic acid, amines, and various other acrylates (Rohm and Haas 2003).

1.4.6 The City of Deer Park Publicly Owned Treatment Works

The City of Deer Park owns and operates a municipal WWTP just south of the Site. This WWTP discharges treated waste water directly into the upper reach of Patrick Bayou.

2 ENVIRONMENTAL DATASETS

The following provides a description of the scope of Site characterization activities that have occurred at the Site, including historical investigations and those performed as part of the RI. The findings of these investigations are the basis for characterizing the environmental setting (Section 3), nature and extent (Section 4), fate and transport of contamination (Section 6), and risk assessments (Section 7).

2.1 Summary of Historical and Third Party Investigations

Historical and third party data that were determined to be useable for the RI/FS and the data evaluation process that was applied to select historical data of suitable quality to supplement RI data in the development of the CSM and support risk assessment are described below. Historical data are defined as environmental data collected at or in the immediate vicinity (e.g., upstream) of the Site boundaries prior to the execution of the AOC. Third party data are defined as data that were not specifically collected in support of the requirements of the AOC but were deemed appropriate to support the objectives of the RI/FS (e.g., total maximum daily load [TMDL] studies and regional fish tissue data).

Several historical environmental investigations were conducted at the Site since the 1990s, as detailed in the Work Package 1 Technical Memorandum (Anchor 2006b). A timeline of historical and third party investigations is provided in Figure 2-1 and summarized in Table 2-1, including the following:

- Houston Ship Channel Toxicity Study (ENSR 1995)
- Contaminant Assessment of Patrick Bayou (Texas Natural Resource and Conservation Commission [TNRCC] and USEPA 1996)
- *Hazard Ranking System Documentation Record,* Patrick Bayou Site, Deer Park, Texas (TNRCC 2001)
- Assessment of Temperature in Patrick Bayou (Parsons 2002)
- Assessment of Sediment Toxicity and Quality in Patrick Bayou (Parsons et al. 2002, 2004)
- TCEQ Surface Water Quality Monitoring Data (TCEQ 2005)
- TCEQ Sediment Bioassay Data (Broach 2008)
- *Total Maximum Daily Loads for Dioxins in the Houston Ship Channel* (Rifai 2006)

- *Total Maximum Daily Loads for PCBs in the Houston Ship Channel* (Rifai and Palacheck 2006, 2007, 2008, 2009, 2010)
- Characterization of Potential Health Risks Associated with Consumption of Fish or Blue Crabs from the Houston Ship Channel, the San Jacinto River (Tidal Portions), Tabbs Bay, and Upper Galveston Bay Texas Department of State Health Services (TDSHS 2005)
- *Health Consultation – Houston Ship Channel and Tabbs Bay* (TDSHS 2001)

2.1.1 Data Usability Review

A detailed data-usability assessment for historical sediment and surface water data is provided in the Work Package 1 Technical Memorandum (Anchor 2006b). Historical (and more recent third party) biological data (tissue, bioassay, and benthic community) were evaluated using a similar approach in the relevant risk assessment work plans and reports (Anchor QEA 2008a, 2008c, 2011a, 2011e, 2012c, 2013a).

The data screening consisted of a two-step process that first identified datasets that were sufficiently recent (samples obtained 1996 or later) and for which adequate documentation of event-, station-, sample- and result-level data were available. If the initial data screening parameters were met for historical or third party investigations, additional data quality indicators were applied and the data were included in the RI/FS environmental database per the data management plan described in the RI Work Plan (Anchor 2007a).

2.1.2 Historical and Third Party Data Selected for Use in the RI/FS

Historical and third party investigation events and samples for surface water, bulk sediment, and biological data that met necessary data quality indicators and were included in the project database for use in the RI/FS are summarized in Table 2-1. These data include the following:

- Bulk sediment chemistry data generated for the TNRCC Hazard Ranking System study (TNRCC 2001).
- Surface water chemistry data generated by TCEQ from 1996 to present.
- Tissue data generated by TCEQ (2010a, 2010b) and (TDSHS 2001, 2005) were considered of acceptable quality and included in the RI/FS database to primarily

support risk assessment.

- Benthic community surveys and sediment bioassay tests performed for the sediment toxicity assessments by Parsons et al. (2002, 2004), and from routine and special monitoring studies performed by TCEQ (Broach 2008) were considered of sufficient quality to support risk assessment.

2.2 Summary of Remedial Investigation/Feasibility Study Investigations

Investigation activities for Site media included sampling and analysis of bulk sediment, porewater, surface water, and biota (i.e., tissue), as well as physical and geotechnical investigations. Consistent with the adaptive management framework adopted for the Site, work was performed as a series of investigations, frequently encompassing several different objectives and media. Results of those investigations were often reported and evaluated in subsequent reports, which were used to identify data gaps and propose additional investigations. As such, this section describes each work plan and report generated as part of the RI/FS in chronological sequence and summarizes the purpose, objectives, and results as appropriate for each. A timeline of RI/FS reports is provided as Figure 2-2. All reports discussed below have been submitted to and approved by USEPA, unless otherwise noted. Subsequent to the chronological discussion, the RI/FS data generated during these Site investigations are summarized by media.

2.2.1 Preliminary Site Characterization Report

In May 2006, the PSCR (Anchor 2006a)[6] was submitted to USEPA, as required by the SOW. The PSCR provided a summary of historical Site data and, using available information, a preliminary Site CSM of contaminant sources, pathways, and receptors. The CSM was developed to guide future investigations and to identify data gaps. Preliminary Applicable or Relevant and Appropriate Requirements (ARARs), preliminary remedial action objectives (PRAOs), and potential remedial technologies were also presented in the PSCR. Finally, the PSCR identified uncertainties and data needs that should be considered in the development of the RI/FS Work Plan (discussed below). The PSCR identified several critical data needs, including the need for vertical characterization of Site sediments, risk assessment Site investigations, and assessment of potential historical or ongoing sources of contaminants to

[6] Dates reflect the final submittal date to USEPA.

the Site. In addition, the PSCR summarized data collected during a bathymetric survey of the Site conducted in 2005. This work was approved by USEPA and included bank-to-bank surveys and mapping of soft sediment thickness[7] across the entire Site.

2.2.2 Work Package 1 Technical Memorandum

In June 2006, the Work Package 1 Technical Memorandum (Anchor 2006b) was prepared to address data gaps identified in the PSCR. These tasks consisted of: 1) a review of historical data and an evaluation of its usability in the RI/FS; and 2) identification of preliminary contaminants of potential concern (PCOPCs) based on a risk-based screening of the historical data. Results of the data usability assessment were the basis for the initial RI/FS project database. The list of PCOPCs identified in the document served as the basis for developing target analyte lists for subsequent investigations and to identify potential data gaps with regard to additional chemicals of interest (COIs) for the RI/FS.

2.2.3 Work Package 2 Work Plan, Hydrodynamic Field Data Collection and Contaminant Source Evaluation and Addendum

In August 2006, the *Work Package 2 Work Plan, Hydrodynamic Field Data Collection and Contaminant Source Evaluation and Addendum* (Work Package 2 Work Plan; Anchor 2006c) was submitted to address data gaps identified in the PSCR. The objectives of Work Package 2 included:

- Develop an understanding of the sediment transport mechanisms and the erosional and depositional characteristics of the Site to support development and calibration of a sediment transport model (STM) that was being developed for the Site.
- Describe the framework for the STM. Elements include initial hydrologic models to support a hydrodynamic model. Data collected during Work Package 2 were necessary to calibrate the initial STM model.
- Conduct a contaminant source evaluation that focuses on evaluating potential ongoing contaminant contributions from off-site sources upstream of the Site.
- Evaluate the depositional history and temporal nature of contaminant sources by vertically profiling the Site sediments for chemical and radiochemical analysis of bulk

[7] Depth of soft sediment was defined as depth at which a manually driven probe reaches refusal.

sediments.

To support these objectives, specific field investigation tasks were developed. These investigations included the following tasks:

- Sediment coring and analysis (chemical and radiochemical)
- Establishment of five data collection platforms (DCPs) within the Site for continuous monitoring of surface water characteristics (e.g., flow, stage, dissolved oxygen, and salinity) for up to 9 months
- Chemical characterization of upstream bulk surface sediment at selected locations

2.2.4 Remedial Investigation Work Plan

In January 2007, and pursuant to requirements of the AOC, the RI Work Plan (Anchor 2007a) was submitted that proposed an overall framework for RI/FS activities, and identified completed/future investigations and tasks necessary to complete the RI. As noted previously, the process outlined in the RI Work Plan was based on an adaptive management approach whereby work was completed, results were evaluated, the understanding of the Site was updated, and future work plans were revised as appropriate. The order of future work was prioritized so that existing and new data were complementary and leveraged towards building a better conceptual understanding of the Site. Accordingly, the RI Work Plan proposed a phased investigation approach with each phase of work described in either work plans or sampling and analysis plans (SAPs) to be reviewed and approved by USEPA prior to initiation. Finally, the RI Work Plan included programmatic documents necessary to guide and perform future RI/FS investigations. These programmatic documents included the Quality Assurance Project Plan, the Data Management Plan, Health and Safety Plan, and Project Management Plan.

2.2.5 Vertical Profiling, Hydrodynamic Field Data Collection and Contaminant Source Evaluation Data Report

In April 2007, the Work Package 2 Report (Anchor 2007b) was submitted to USEPA, providing the results of field activities identified in Work Package 2 (discussed above), preliminary analysis of the results, and recommendations for additional investigations. Results included vertical distribution of PCOPCs in Site sediments from multiple representative locations, vertical radiochemistry profiles (cesium-137) from sediment cores, upstream surface bulk sediment chemistry of PCOPCs, and initial results of continuous measurement of surface water characteristics. The evaluation of these data, along with existing data, concluded that:

- The lateral and vertical distribution of PCOPCs was well characterized.
- The timing of contaminant loading could be discerned with a high degree of confidence in various parts of the Site based on the vertical profiles of PCOPCs in the cores.
- Sediment profiles of PCOPCs and cesium-137 collected during the investigation provided a basis for estimating historical and current rates of sedimentation and potential rates of recovery in surface PCOPCs.

2.2.6 Supplemental Work Plan

Following issuance of the Work Package 2 Report, discussed above, the Supplemental Work Plan (Anchor 2007c) was submitted in May 2007. The Supplemental Work Plan described a scope of work that included additional field investigation to fill data gaps identified in the RI Work Plan and Work Package 2 Report.

The scope of work was specifically developed to help address data gaps concerning potential remedial actions at the Site that would involve sediment caps/covers, monitored natural recovery (MNR), or enhanced MNR. In addition, bed stability and sediment loading data would be collected to develop and calibrate the STM linked to the hydrodynamic model initially developed as part of Work Package 2. Data gaps to address remedial alternatives and the STM fell into the following four general categories:

- Determination of hydrodynamic stability of bed sediments
- Evaluation of recent sediment quality, accumulation rates, and loading
- Evaluation of geotechnical properties of sediments within the Site
- Evaluation of contaminant flux from porewater into clean cover materials (either natural or imported cover materials) and surface water

To address these data gaps in the CSM, specific field investigations were identified, including:

- Collection of sediment cores to characterize the velocities and shear stresses required to initiate erosion of sediments from representative areas of the Site and to determine subsequent potential erosion rates (i.e., Sedflume)

- Lead-210 analysis in sediment cores to characterize recent sediment accumulation rates
- Placement of marker horizons to evaluate current rates of sediment accumulation or erosion
- Utilizing sediment traps to characterize PCOPC levels entering the Site in suspended sediments from upstream areas
- Characterization of PCOPCs in porewater and residual sediment solids collected from surface bulk sediments
- Collection of samples to evaluate geotechnical properties of Site sediment for the FS

2.2.7 Selection of Contaminants of Potential Concern for Ecological Risk Assessment and Amendment

In April 2008, the *Selection of Contaminants of Potential Concern for Ecological Risk Assessment Technical Memorandum* (Anchor 2008a) was issued, providing screening, selection, and refinement of the list of PCOPCs to identify contaminants of potential concern (COPCs) for the Ecological Risk Assessment (ERA), as required by the AOC. An amendment (Anchor 2008c) to this report was issued in October 2008 based on comments received from USEPA, TCEQ, and the trustees. This report evaluated historical and RI/FS bulk sediment, surface water, and biological (i.e., whole sediment bioassay) data using risk-based methodology to identify ecological COPCs to be considered in the BERA.

2.2.8 Mixing Zone Evaluation Work Plan

The *Mixing Zone Evaluation Work Plan* (Mixing Zone Work Plan; Anchor 2008b) was submitted in November 2008 to supplement data collected under Work Package 2 and the Supplemental Work Plan (discussed above). The purpose of this work was to improve the validation and calibration of the STM and to define the surface sediment mixing zone[8]. Data collected to support this evaluation included characterization of the top 20 centimeters (cm) of surface sediment at representative locations. Characterization included analysis of

[8] Vertical extent of the sediment bed where active physical mixing occurs due to biological burrowing (bioturbation) and hydrodynamic forces.

selected PCOPCs, age dating using radioisotopes (lead-210) to determine net sedimentation rates (NSRs), and physical bulk sediment properties for engineering analyses (e.g., grain size and bulk density) in discrete 2 cm intervals from each core.

2.2.9 Geotechnical Data Report

The *Geotechnical Data Report* (Anchor 2008d) was submitted in June 2008 to describe the results of geotechnical sampling performed as part of the Supplemental Work Plan investigations. Results of tests performed on overlying soft sediment, as well as the underlying Beaumont Clay, are described. Testing included geotechnical index properties, in situ shear strength, settlement properties, and hydraulic conductivity.

2.2.10 Selection of Great Blue Heron or Green Heron as Receptor of Concern Memorandum

The *Selection of Great Blue Heron or Green Heron as Receptor of Concern Memorandum* (Anchor QEA 2009a) was issued in February 2009 following a discussion regarding a representative receptor for the carnivorous wading bird feeding guild for the BERA at a technical work group (USEPA, TCEQ, Trustee, and JDG representatives) meeting in January of that year. The memorandum compared and contrasted the behavioral, physiological, and life history information of the great blue heron and the green heron to provide relevant information to support the selection of an appropriate receptor. Neither species was deemed a representative receptor for this guild due to the wide range of body weights, energetic requirements, and feeding habits of this group. Rather a composite body weight approach was chosen to represent the feeding guild for the BERA. The composite receptor included the body weight and ingestion rates of the great blue heron, great egret, roseate spoonbill, white ibis, and green heron.

2.2.11 Sediment Mixing Zone Layer Study Memorandum

In June 2009, the *Sediment Mixing Zone Layer Study Memorandum* (Mixing Zone Memo; Anchor QEA 2009b) was submitted to summarize the results of November 2008 field activities identified in the Mixing Zone Work Plan (Anchor 2008b; discussed above). The maximum mixing zone layer was determined to be 10 cm or less in different areas within the Site based on vertical profiles of selected PCOPCs and lead-210. The NSRs and mixing layer thickness obtained in the study were used as calibration and validation parameters in the STM.

2.2.12 Surface Sediment Contaminant of Potential Concern Delineation and Surface Water Sampling and Analysis Plan

The *Surface Sediment Contaminant of Potential Concern Delineation and Surface Water Sampling and Analysis Plan* (COPC SAP; Anchor QEA 2009c) was submitted in September 2009, based on review of data obtained through Work Package 2 Work Plan (Anchor 2006c) and the Supplemental Work Plan (Anchor 2007c). Although historical data for surface sediments was available from TMDL evaluations and Work Package 2 investigations, the vertical characterization and STM (described above) suggested that sediment concentrations had declined due to attenuation, natural recovery, and sedimentation occurring in the Site. The field investigations proposed in the COPC SAP were developed to provide information that would allow further development of the CSM and provide additional baseline data for the Site risk assessments. The investigations involved collection of surface sediment samples representative of the mixed/bioactive layer over the entire extent of the Site. Surface water sampling was proposed to fill the data gap for several COIs that existed for that medium based on prior risk analyses.

2.2.13 Sediment and Surface Water Contaminant of Potential Concern Delineation Data Report

In May 2010, the *Sediment and Surface Water Contaminant of Potential Concern Delineation Data Report* (COPC Data Report; Anchor QEA 2010) was submitted to USEPA summarizing the results of the field investigations that took place in October and November 2009 in accordance with the COPC SAP (described above). The objectives of the investigation were to determine the distribution of COPC concentrations within the mixing layer of the surface sediments and to refine the surface water COPC list, which was previously incomplete. The results described in the data report were used to assist in further development of the CSM and to provide baseline data for risk assessments.

2.2.14 Baseline Ecological Risk Assessment Work Plan

The *Baseline Ecological Risk Assessment Work Plan* (BERA Work Plan; Anchor QEA 2011a) outlined the approach and methods to be used in the BERA (described below). The document was submitted in May 2011 as required by Task 4 of the SOW. Activities described in the BERA Work Plan included:

- Refinement of list of ecological COPCs to be evaluated in the BERA
- Identification of representative ecological receptors and potential exposure pathways
- Exposure and effects assessments for each receptor group and pathway
- Risk analysis and characterization approaches for each receptor group
- Uncertainty analysis

The BERA Work Plan identified tissue data as a data gap in the exposure assessment for ecological receptors. A SAP to address this data gap was included as an attachment to the BERA Work Plan (Ecological Tissue SAP; Anchor QEA 2011b).

2.2.15 Upstream Characterization Sampling and Analysis Plan

The *Upstream Patrick Bayou Characterization Sampling and Analysis Plan* (Upstream Characterization SAP; Anchor QEA 2011c) was submitted in June 2011 as an extension of the COPC SAP, which identified previously unknown concentrations of polychlorinated biphenyls (PCBs) and polycyclic aromatic hydrocarbons (PAHs) in the upstream area of the Site. The objectives outlined in this SAP were to fill in data gaps related to the nature and extent of PCBs and PAHs in upstream bulk sediments and surface water, and to determine the extent of COPCs that could enter the Site from upstream sources outside of the Site boundary. Field investigations included soft sediment mapping, field and analytical laboratory analysis of bulk sediment for selected COPCs, and surface water sampling and analysis of selected COPCs within the upstream areas (i.e., upstream of PB-065).

2.2.16 Baseline Human Health Risk Assessment Work Plan

The *Baseline Human Health Risk Assessment Work Plan* (BHHRA Work Plan; Anchor QEA 2011d) was submitted in August 2011 in accordance with Task 4 of SOW. The document identified the assumptions and information required to characterize the potential risks to human health from Site COPCs, including:

- Identification of human health COPCs
- Evaluation and identification exposure pathways and toxicity assessment of COPCs
- Risk characterization methodology
- Uncertainty assessment

The BHHRA Work Plan (Anchor QEA 2011d) identified tissue data as a data gap in the exposure assessment for human health. A SAP to address this data gap was included as an attachment to the BHHRA Work Plan (Human Health Tissue SAP, Anchor QEA 2011e).

2.2.17 Upstream Patrick Bayou Characterization Data Report

The *Upstream Patrick Bayou Characterization Data Report* (Upstream Data Report; Anchor QEA 2012a) summarized the field investigations performed in accordance with the Upstream Characterization SAP (Anchor QEA 2011c). Results of investigations included mapping of soft sediments, field and laboratory analysis of PCBs and PAHs in surface bulk sediment samples, and laboratory analysis of PCBs in surface water samples.

2.2.18 Sediment Transport Modeling Report

The final version of the *Sediment Transport Modeling Report* (Anchor QEA 2012b) was submitted in April 2012 and is pending approval by USEPA. Because sediment transport processes have an effect on the fate and transport of particle-associated COPCs, a numerical model was developed as a quantitative tool for evaluation of short-term and long-term sediment transport activities at the Site. The hydrology of the surrounding watershed and the hydrodynamics and sediment transport within the Site were described. The results of the modeling report provide a critical foundation for assessing contaminant fate and transport at the Site and provide a tool to evaluate different remedial technologies and alternatives in the FS.

2.2.19 Baseline Human Health Risk Assessment Report

The BHHRA Report (Anchor QEA 2012c), which was submitted in December 2012, presented the results of the baseline risk assessment for human receptors. The BHHRA Report characterized the potential site-related risks to human health resulting from the presence of COPCs in Site media, as presented in the BHHRA Work Plan (Anchor QEA

2011d). The document assessed all known and suspected sources of chemical contamination, types of chemicals and affected media, known and potential routes of migration, and known or potential human receptors.

To fill any data gaps present in the exposure assessment for human health, fish and invertebrate tissue samples were collected and analyzed for COPCs in 2011 consistent with the Human Health Tissue Work Plan. A data report summarizing the results of this sampling event was included as an attachment to the BHHRA Report (Anchor QEA 2012c).

2.2.20 Baseline Ecological Risk Assessment Report

The BERA Report (Anchor QEA 2013a) was submitted to USEPA in March 2013. This report presented a characterization of potential site-related risks to ecological receptors resulting from the presence of COPCs in Site media, as presented in the BERA Work Plan. The document assessed all known and suspected sources of chemical contamination, types of chemicals and affected media, known and potential routes of migration, and known or potential ecological receptors. Risk assessments were conducted for wildlife, fish, and benthic and aquatic invertebrates.

To fill any data gaps present in the exposure assessment for ecological receptors, fish and invertebrate tissue samples were collected and analyzed for ecological COPCs in 2011. A data report summarizing the results of this sampling event was included as an attachment to the BERA Report.

2.2.21 Remedial Alternatives and Technology Screening Report

In May 2013, the *Remedial Alternatives and Technology Screening Report* (Anchor QEA 2013b) was submitted to USEPA. Approval is pending. This document developed and screened an appropriate range of preliminary remedial technologies for the Site in relation to the PRAOs. Results of these evaluations will be carried forward for further consideration in the Site FS.

The objectives of the *Remedial Alternatives and Technology Screening Report* (Anchor QEA 2013b) were to:

- Develop PRAOs for the Site. Identify and screen remedial technologies (such as monitored natural recovery, sediment containment, sediment removal, or sediment treatment) to eliminate candidate remedial technologies that cannot be implemented, or that may be limited in their applicability due to technical or other constraints at the Site.
- Identify and screen potential disposal alternatives for removed contaminated sediment and eliminate disposal process options that are not practical to implement.
- Identify the preliminary ARARs for the protection of human health or the environment at the Site.

2.3 Summary of Environmental Data by Media

The data collected in support of the RI were often multifaceted and performed in an interactive fashion consistent with the adaptive framework for the Site. For many media, multiple rounds of sampling were performed. This section summarizes the available data by media based on the RI, historical, and third party studies described in the previous sections.

2.3.1 Physical Data

Several field investigations were designed to develop a greater understanding of the Site physical system. In addition to the field investigations performed specifically as part of the RI, several third party sources of information were selected to support the development of the CSM. These data are summarized below.

2.3.1.1 Bathymetric Data

As part of the pre-AOC RI studies, a bank-to-bank bathymetric survey was conducted in 2005 by Gahagan and Bryant Associates, Inc. (GBA), for the Site and areas immediately upstream (south of SH 225) and downstream (within the proximal portions of the HSC). The primary goal of the survey was to develop an accurate baseline riverbed elevation database for the Site. The accuracy of the survey was reported to not exceed ± 0.2 foot vertical and ±1.0 foot horizontal. Results of the survey are presented in the PSCR (Anchor 2006a).

2.3.1.2 Soft Sediment Thickness

To identify potential sediment deposition zones, soft sediment thickness was measured throughout the Site and immediately upstream and downstream during the bathymetric survey. Soft sediment thickness was measured using a steel rod that was manually pushed into the sediment until it could not be advanced further (refusal). Although this measurement does not provide a quantitative measurement of material strength, it does provide an indication of depositional areas and thicknesses of fine-grained sediments at the Site.

2.3.1.3 Light Detection and Ranging Data

To facilitate characterization of the upland area surface topography, the results of a bare Earth light detection and ranging (LiDAR) survey of the Houston area performed in February and March 2008 were purchased from the Houston-Galveston Area Council (H-GAC 2013). This is the most recent LiDAR survey available and provides 5-foot horizontal pixel resolution with 0.22-feet vertical resolution. The LiDAR data were collected using an ALS50 Phase 2 sensor, and the raw data were verified in MARS software. The dem_q29095f11 and dem_q29095f22 ESRI grid files received from H-GAC were derived from boresighted LiDAR data and filtered by last return (Bare Earth). The LiDAR data have been used to generate high-resolution digital elevation models to represent surface topography of the upland areas in 5-foot cell size, with a vertical accuracy of 0.22 feet.

2.3.1.4 Continuous Surface Water Monitoring Investigations

Continuous measurements of surface water velocity, elevation, conductivity, temperature, and dissolved oxygen were collected from October 2006 to October 2007 at five locations within the Site. These data were collected to support the sediment transport modeling and CSM. DCPs were established at the locations shown in Figure 2-3 during the week of October 2, 2006. Data collection was initiated on October 11, 2006, and ended on October 16, 2007. Data were collected at 15 minute intervals during the period of record. Calibration checks, Site maintenance, and data downloads were performed at routine intervals during the monitoring period. One DCP (PB-020) was lost during a strong storm on August 9, 2007, and was not recovered.

In addition, samples for total suspended solids (TSS) were collected using portable autosamplers at three locations during October to November 2006 (Figure 2-4). Discrete samples were collected every three hours between October 11, 2006, and November 6, 2007. Collected samples were analyzed corresponding to storm events during the monitoring period. Samples collected during three storm events were submitted and analyzed for TSS, along with periodic[9] samples during baseline conditions (i.e., no recorded rainfall). These data were used to support calibration of the sediment loading for the STM.

2.3.1.5 Sediment Deposition and Accretion Rate Investigations

Rates of sedimentation were investigated using vertical sediment cores analyzed for radiochemical parameters on two separate occasions. In October 2006, five sediment cores from areas of deepest soft sediment accumulation were collected from within the Site (Figure 2-5). These cores were sampled at continuous 4-cm intervals along their length. Every other interval (e.g., 0 to 4 cm and 8 to 12 cm) was analyzed for cesium-137. In general, two marker horizons were identified, 1954 and 1963, representing the initial occurrence and highest concentration of cesium-137[10]. Using the depth of these horizons in the sedimentary record, an average sediment deposition rate is calculated. The estimated sedimentation rates in turn allow an evaluation of the historical record of COPC loading to be constructed.

To evaluate shorter term sedimentation rates, another isotope, lead-210, was analyzed in ten cores collected from the Site in November 2008 (Figure 2-5). Cores were sampled at continuous 2-cm intervals along their length (approximately 20 cm). Every other interval (e.g., 0 to 2 cm and 4 to 6 cm) was analyzed for lead-210. In aquatic environments, the approximately constant atmospheric flux of lead-210 and its decay half-life of 22.3 years results in relatively homogeneous lead-210 activities within the biologically-active surface layer of the sediments and activities that decay exponentially below this depth. For this reason, lead-210 was selected to evaluate near-term NSRs and to identify depth of the mixing zone at the Site.

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[9] Every 12th sample (i.e., every 36 hours) was analyzed for TSS during period of no recorded rainfall.
[10] Cesium-137 is associated with thermo-nuclear bomb testing in the 1950s and 1960s (Simpson et al. 1976).

Finally, to evaluate current and ongoing rates of sediment accretion, marker horizons plots were established at several locations within the Site (Figure 2-6). Marker horizons were established using a thin layer of white feldspar placed on top of the existing surface sediment. Marker horizon plots would be sampled at regular intervals to measure sediment accumulation (accretion) above the marker horizon. Marker horizons were established the week of July 9, 2007. At the first scheduled sampling event, no feldspar horizons were present. It is hypothesized that a significant storm in August, 2007 resulted in extremely high surface velocities that may have eroded the marker horizons. The STM model predicted that the bed shear stress equaled or exceeded predicted critical shear stresses at six out of the seven marker-horizon locations during the high-flow event that occurred on August 16-17, 2007 which was less than 6 weeks after the marker-horizon material was laid down. This was an approximate 10-year flood and was the largest flood of that year[11]. Thus, no data were collected for this particular field investigation task. Marker horizons were not re-established.

2.3.1.6 Sediment Erosion Properties

A study was conducted to obtain data on the erosion properties of Site sediments. Twelve cores were collected in June 2007 from 12 locations in the Site (see Figure 2-7). Erosion rates as a function of depth in the sediment bed and shear stress were measured in the laboratory over the top 30 cm of each core using a Sedflume[12]. Sediment samples were also obtained at 5-cm intervals from each core and analyzed for bulk density and grain size distribution.

2.3.1.7 Geotechnical

Geotechnical sampling was conducted as part of the Supplemental Work Plan investigations (Anchor 2007c) and results are reported in the *Geotechnical Data Report* (Anchor 2008d). Sampling locations are shown in Figure 2-8. Analysis of Site sediments included geotechnical index properties, in situ shear strength, settlement properties, and hydraulic conductivity. Specifically, six sediment cores were collected and analyzed for water content, specific gravity, Atterberg limits, and grain size. Vane shear tests were performed at 12

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[11] A more detailed discussion of the marker-horizon analysis is provided in the *Sediment Transport Modeling Report* (Anchor QEA 2012b).

[12] A full description of the Sedflume is provided in the Supplemental Work Plan (Anchor 2007c).

locations over multiple depths to evaluate in situ undrained shear strength of Site sediments. Finally, the settlement characteristics of the surficial sediments were measured using the laboratory Seepage Induced Consolidation Test on sediments collected at three locations. This test provides information on settlement at very low loads using a differential hydraulic force across a remolded sample to measure several parameters for the sample (Abu-Hejleh and Znidarcic 1996).

2.3.2 Bulk Sediment

Sediment chemistry data in the RI dataset include surface (0 to 10 cm) and subsurface (greater than 10 cm) samples from investigations described in Sections 2.1 and 2.2. Historical investigations included in the RI database are primarily associated with concurrent sampling for benthic community assessments and sediment toxicity studies. Sediment samples collected as part of RI efforts focused on: 1) characterizing the vertical extent of contamination; 2) characterizing upstream bulk sediment contamination; 3) defining the depth of the mixing zone; and 4) characterizing the lateral extent of contamination within the mixing zone. Historical and RI related sediment sampling efforts are summarized in the following sections and in Table 2-1 and Table 2-2 respectively.

2.3.2.1 Historical Sediment Sampling

In 1993 and 1994, the City of Houston performed a toxicity study in the HSC and its tributaries (ENSR 1995). This study was performed in response to a consent decree (Civil Action No. 91-3072) the City of Houston entered into with USEPA on March 9, 1992. The consent decree required that the City of Houston conduct a remedial project, including water and sediment chemistry, toxicity testing, and fish tissue chemistry. The project area included the Site as a tributary to the HSC and three stations were sampled there during the study (Stations 014, 015, and 016 on Figure 2-9).

In 1994, TNRCC and USEPA Region 6 (USEPA 2001) conducted a follow-up investigation, which confirmed the initial findings and greatly expanded the area of documented contamination. Eleven stations, including TNRCC routine monitoring Station 11273[13], were chosen for sampling and analysis. Samples were collected in an area that extended from the

[13] TNRCC renamed routine monitoring station 11273 to 2.5 for this investigation.

HSC just downstream of the confluence with the Site to just upstream of SH 225 and the City of Deer Park WWTP outfall (Stations 1, 2, 2.5, 3, 4, 5, 6, 7, 8, 9, and 10; Figure 2-9). Eleven surface sediment samples were analyzed for priority pollutants, including metals, volatile organic compounds (VOCs), semi-volatile organic compounds (SVOCs), pesticides, and PCBs.

In 2000, TNRCC and USEPA Region 6 (USEPA 2001) collected 13 Site and nine off-Site sediment samples as part of a Preliminary Assessment/Screening Site Inspection performed to determine if the Site was eligible to be proposed for addition to the NPL under the Superfund program. Bulk sediment chemistry was performed on the collected samples for metals, VOCs, SVOCs, pesticides, and PCBs. Off-site samples were collected from reaches of the Site upstream of the City of Deer Park WWTP outfall, the East Fork Tributary upstream of the Praxair outfall, and the HSC upstream of the confluence with the Site. Station locations (SE-01 through SE-05, SE-07, SE-08, SE-10 through SE-12, SE-14, SE-15, SE-17 through SE-20, and SE-22 through SE-27) are identified in Figure 2-9.

In 2000 and 2001, the TMDL Working Group (Parsons et al. 2002) collected samples for bulk sediment chemistry on- and off-Site, in addition to toxicity testing and benthic community analysis described in Section 2.3.6.2 and 2.3.6.3, respectively. Stations sampled included ten previous TNRCC sampling locations and nine additional stations (Stations 2, 2.5, 3, 4A, 5, 6A, 7 through 10, E, G, Q through V, and Y on Figure 2-9). All 19 stations were sampled in September 2000, while 18 were sampled in April 2001 (sediment was not present at Station 9 in April). Bulk sediment chemistry, including analysis for VOCs, SVOCs, metals, polychlorinated dibenzodioxins and polychlorinated dibenzofurans (PCDDs/PCDFs), PCBs, and pesticides, was performed on all sediment samples. Bulk sediment sampling was repeated in 2003 for eight of the 2000 and 2001 stations (Parsons et al. 2004).

2.3.2.2 Vertical Sediment Characterization

In October 2006, sediment cores were collected at 14 stations (Figure 2-10). Each core was then sectioned into various depth intervals for bulk sediment chemistry. The first interval was 0 to 11 cm (surface interval). Subsequent subsurface intervals were approximately 30 cm. Co-located sediment surface grabs were also collected over the 0 to 2 cm interval using a sediment grab sampler (i.e., Ekman dredge).

Bulk chemistry samples collected for the vertical profiling investigation were analyzed for metals, mercury, PCDDs/PCDFs, PAHs, pesticides, SVOCs, VOCs, PCB Aroclors, PCB congeners, conventional parameters (e.g., total organic carbon [TOC]), total solids, and grain size. Vertical sediment characterization investigations are summarized in Table 2-2. Full results of the vertical sediment chemistry investigation can be found in the Work Package 2 Report (Anchor 2007b).

2.3.2.3 Upstream Characterization

Sediment samples were collected from upstream of the Site boundary in November 2006 and August 2011 (Figure 2-11). Four stations were sampled in 2006 for surface sediments (0 to 2 cm below the mud line). Bulk chemistry samples were analyzed for metals, mercury, PCB Aroclors, PAHs, SVOCs, VOCs, pesticides, conventional parameters (e.g., TOC), and total solids.

The 2011 sampling event included an investigation of the sediments in the five culverts beneath SH 225 for sediment condition and vertical composition of the sediment. Sediment was collected from 0 to 10 cm in four of the culverts. In the fifth culvert, sediment was sampled in 30 cm intervals from 0 to 90 cm. Samples were analyzed for grain size, TOC, specific gravity, metals, PAHs, PCB congeners, and PCDDs/PCDFs. Upstream sediment characterization investigations are summarized in Table 2-2. Full results of this investigation can be found in the *Upstream Data Report* (Anchor QEA 2012a).

2.3.2.4 Mixing Zone

In November 2008, sediment cores were collected from the approximately top 20 cm layer of sediment at ten locations shown in Figure 2-5 (the same cores sampled for analysis of lead-210, as described in Section 2.3.1.5). For each core, samples were collected in 2 cm intervals from five different depths (0 to 2 cm, 4 to 6 cm, 8 to 10 cm, 12 to 14 cm, and 16 to 18 cm). Samples were analyzed for lead-210 (see Section 2.3.1.5), PCB Aroclors, mercury, hexachlorobutadiene, PAHs, TOC, density, and total solids. A composite sample of the entire core was also collected for grain size analysis. Mixing zone investigations are summarized in Table 2-2. Full results of the mixing zone evaluation can be found in the Mixing Zone Memorandum (Anchor QEA 2009b).

2.3.2.5 Lateral Characterization

In 2006, 2009, and 2011, field investigations were conducted for sediments to provide a synoptic, site-wide understanding of the distribution of COPC concentrations (Figure 2-12). All samples were collected from 0 to 10 cm (with the exception of the 2006 sampling event, which collected surface samples from 0 to 11 cm). Lateral characterization investigations are summarized in Table 2-2. The 2006 surface sediment samples were collected as part of the sediment vertical characterization. A full description of this sampling event is provided in Section 2.3.2.2.

In October and November of 2009, 46 locations within the Site boundary were sampled using a box core and Ekman dredge. Sample locations were based on an approximate 300-foot grid spacing coverage. Samples were analyzed for grain size, TOC, ammonia, acid volatile sulfides and simultaneously extracted metals (AVS/SEM), metals, PAHs, SVOCs, VOCs, PCB congeners, pesticides, and PCDDs/PCDFs. The AVS/SEM samples were collected from the top 2 cm of the box core samples and all other analytes were collected from the entire 0 to 10 cm interval. Complete analytical results from this investigation can be found in the COPC Data Report (Anchor QEA 2010).

In August of 2011, 15 sediment samples were collected from the upstream portion of the Site (from Stations PB-066 to PB-101) using an Ekman dredge and analyzed for PCB Aroclors using on-site PCB field assay test kits. Of those 15 samples, six were sent for confirmation analysis by an off-site laboratory for PCB Aroclors and PAHs. Full results from this investigation can be found in the *Upstream Data Report* (Anchor QEA 2012a).

2.3.3 Porewater

Samples for porewater analysis of metals (including mercury speciation), SVOCs, pesticides, PCB congeners, and phthalates were collected from ten sampling locations in July and August 2008. Peepers for VOC analysis in porewater were deployed during this timeframe at each of the ten sample locations. Peepers were retrieved in September 2008; however, only five of the ten peepers were located and retrieved. Porewater sample locations are shown on Figure 2-13.

For SVOC, phthalates, pesticides, PCB congeners, metals (excluding mercury speciation), and conventional parameters, sediment samples for porewater extraction were collected using a standard Ekman dredge. Sediment was taken from the 0- to 10-cm interval. For VOC analysis, sediment peepers were constructed and deployed at each of the ten locations. Upon retrieval, peepers were processed in the field with a hypodermic needle and clean syringe, which was used to extract the equilibrated sample water from the peeper sample chambers. For mercury speciation analysis, samples were collected using box core driven into the sediment to a sufficient depth to retrieve at least the top 20 cm. The sediment core was extruded to obtain 2-cm interval samples from the top 20 cm, centrifuged on-site, and filtered through 0.45 micron nitrocellulose filters[14].

2.3.4 Suspended Sediment

Sediment traps were used to sample suspended particulate material in the Site. Sediment trap sample locations were selected as far upstream as practical in the East Fork (EF-001) and the main channel of the Site (PB-077) to collect samples representative of new sediment entering the Site from upstream sources (Figure 2-14). The sediment traps were sampled at approximately four week intervals to allow sufficient volume of material for the required analytical analyses to be collected. A total of six samples were collected from PB-077 between September 2007 and April 2008. Five samples were collected from EF-001 between October 2007 and April 2008. Sediment trap samples were analyzed for PCB congeners, SVOCs, PAHs, metals, mercury, pesticides, and total solids.

2.3.5 Surface Water

Surface water chemistry data in the RI dataset are made up of samples from investigations described in Sections 2.1 and 2.2. Historical data included in the RI database are primarily associated with routine and special monitoring activities performed by state and federal agencies. Surface water samples collected to specifically support the RI focused on: 1) refining the surface water COPC selection list by eliminating data gaps due to limited or no surface water data; and 2) providing a synoptic, site-wide understanding of the

[14] All mercury porewater sampling processing was performed under a blanket of nitrogen to avoid oxidation by atmospheric oxygen.

distribution of COPCs in surface water. These investigations are described below and summarized in Table 2-3.

2.3.5.1 *Historical Surface Water Sampling*

In 1993 and 1994, the City of Houston collected surface water samples as part of a toxicity study in the HSC and its tributaries (ENSR 1995). This investigation is described in Section 2.1. In 1994, TNRCC and USEPA Region 6 (USEPA 2001) conducted a follow-up investigation, which confirmed the initial findings and expanded the area of potential contamination. Samples were collected in an area that extended from the HSC just downstream of the confluence with the Site to just upstream of SH 225 and the City of Deer Park WWTP outfall. Five surface water samples were analyzed for routine water chemistry (USEPA 2001).

2.3.5.2 *RI Surface Water Sampling*

Surface water was collected during two sampling events (November 2009 and August 2011; Figure 2-15). These sampling events occurred concurrently with the 2009 and 2011 sediment investigations described in Section 2.3.2.5.

During the 2009 sampling event, 22 samples were collected from four locations within the Site boundary and three locations outside the Site boundary. Water samples were collected using a horizontal van Dorn bottle. Samples were collected from mid-depth of the water column and approximately 6 inches from the bottom at each location. Collection occurred during two tidal conditions: one at approximately slack low tide and the second at approximately mid-tide (ebb tide). Surface water samples were analyzed for SVOCs, PAHs, VOCs, pesticides, PCB congeners, PCDDs/PCDFs, selenium and mercury (both total and dissolved), total Kjeldahl nitrogen, and conventional water quality parameters. Complete analytical results from this investigation can be found in the COPC Data Report (Anchor QEA 2010).

During the 2011 surface water investigation, four surface water samples were collected from within the boundaries of the 2011 investigation area (Station PB-066 to PB-101). Samples were collected using a peristaltic pump from the mid-depth of the water column during an ebb tide. Samples were analyzed for TOC, TSS, and PCB congeners. Full results from this investigation can be found in the Upstream Data Report (Anchor QEA 2012a).

2.3.6 Biota

Biota chemistry data in the RI dataset are made up of samples from investigations described in Sections 2.1 and 2.2. Biota chemistry data are comprised of fish and invertebrate tissue samples, sediment toxicity studies, and benthic community assessments. The historical investigations for sediment toxicity studies and benthic community assessments are primarily associated with concurrent sampling for bulk sediment chemistry. Invertebrate and fish tissue samples collected to support the RI focused on: 1) filling data gaps in the fish and wildlife exposure assessment to refine the baseline exposure assessment for aquatic and wildlife receptors; and 2) measuring contaminant exposure levels to determine whether COPCs at or near the Site are affecting or could potentially affect human health. These investigations are described below and summarized in Table 2-4.

2.3.6.1 Historical Tissue Investigations

Several PCDD/PCDF and PCB TMDL studies involving tissue sampling have been completed in the HSC (TCEQ 2010a, 2010b). In 2002 and 2003, 33 fish and 48 shellfish were collected as part of the initial TMDL investigation. Both species were analyzed for PCDD and PCDF congeners. Additionally, shellfish were analyzed for PCB congeners. These data were reported by Howell et al. (2008; in TCEQ 2010a, 2010b). Additional sampling for fish tissue was conducted in 2008 and 2009 (Rifai 2009; in TCEQ 2010a, 2010b). Also, 25 fish samples were collected and analyzed for PCB congeners. During both studies, several locations were sampled in the HSC and tributaries between Patrick Bayou and the San Jacinto Monument Park (Figure 2-16).

2.3.6.2 Remedial Investigation Tissue Sampling

Tissue chemistry data from the Site included in the RI/FS dataset were collected during June 2011 in support of the BERA exposure assessment and in September and October 2011 in support of the BHHRA exposure assessment.

Invertebrate tissue data included in the BERA dataset include samples for blue crabs (*Callinectes sapidus*), brown shrimp (*Penaeus aztecus*), white shrimp (*Penaeus setiferus*), and oysters (*Crassostrea virginica*). A total of 33 invertebrate samples were collected, including 21 blue crab samples, eight brown shrimp samples, three white shrimp samples, and one oyster sample (Figure 2-17). Invertebrates were divided into two size classes, 2 to 7.5 cm and 7.5 to 13 cm, representing the prey sizes ingested by the wildlife receptors identified in the BERA Work Plan. Samples were analyzed for wildlife COPCs identified in the BERA Work Plan (Anchor QEA 2011a), including lead, total mercury, PCB congeners, PCDDs/PCDFs, PAHs, hexachlorobenzene, 1,3-dichlorobenzene, hexachlorobutadiene, and 1,4-dichlorobenzene. Complete analytical results from this investigation can be found in the *Ecological Fish and Invertebrate Tissue Sampling Data Report* (attachment to the BERA Report [Anchor QEA 2013a]).

Fish tissue data included in the BERA dataset include samples of Gulf killifish (*Fundulus grandis*), Gulf menhaden (*Brevoortia patronus*), pinfish (*Lagodon rhomboides*), sand seatrout (*Cynoscion arenarius*), and striped mullet (*Mugil cephalus*). A total of 50 fish samples were collected: 25 Gulf killifish, ten Gulf menhaden, four pinfish, two sand seatrout, and nine striped mullet (Figure 2-18). All fish collected for analysis were less than 15 cm (total length) based on the assumed prey size for the wildlife receptors identified in the BERA Work Plan (Anchor QEA 2011a). Fish tissue was analyzed for both fish and wildlife COPCs identified in the BERA Work Plan, including total mercury, hexachlorobenzene, 1,3-dichlorobenzene, PCB congeners, and PCDDs/PCDFs. Complete analytical results from this investigation can be found in the *Ecological Fish and Invertebrate Tissue Sampling Data Report* (attachment to the BERA Report [Anchor QEA 2013a]).

A comprehensive fish and shellfish tissue sampling effort was performed in September and October 2011 in support of the BHHRA exposure assessment. As described in the *Human Health Tissue Sampling and Analysis Plan (*Anchor QEA 2011e), the study targeted species and size classes of fish and shellfish species that recreational fishermen could legally collect in the State of Texas. Although the study design included all recreationally caught and consumed species, hardhead catfish and blue crabs were the only species caught during the investigation.

During the investigation, 33 hardhead catfish and 20 blue crab samples were submitted for analysis of PCDDs/PCDFs, and PCB congeners. Figure 2-19 presents the locations where hardhead catfish and blue crabs were caught at the Site. The hardhead catfish and blue crabs were within the targeted fish body size of 30 cm (12-inch total length) and for blue crabs, carapace width greater than 13 cm (5-inch minimum body width as measured from spine to spine) (TPWD 2010a, 2010b). Edible tissue (skinless fish fillet and blue crab claw and carapace meat) samples were collected and analyzed. Complete analytical results from this investigation can be found in the *Human Health Fish and Shellfish Tissue Sampling Data Report* (attachment to the BHHRA Report [Anchor QEA 2012c]).

2.3.6.3 Bioassay

Toxicity studies related to the Site are summarized in this section. Sediment toxicity sampling stations are shown in Figure 2-20.

2.3.6.3.1 Assessment of Sediment Quality in Patrick Bayou

Toxicity studies included whole sediment and porewater toxicity investigations (Parsons et al. 2002).

Whole Sediment

Toxicity tests were performed using sediment from 20 sampling locations in September 2000 and April 2001, including locations sampled during prior testing. Testing consisted of 10-day exposures of the amphipod *Leptocheirus plumulosus* and the polychaete *Nereis virens* to sediments.

Porewater

Based on the results of the initial whole sediment toxicity testing, four sampling locations were selected for 96-hour acute tests using porewater extracted from sediment collected in October 2000. *L. plumulosus* was selected as the test organism. Porewater toxicity tests were again performed on selected sediments following the April 2001 whole sediment toxicity tests. Samples selected for porewater toxicity testing were those that demonstrated toxicity in the whole sediment and included both *L. plumulosus* and *N. virens* test organisms.

2.3.6.3.2 Assessment of Sediment Quality in Patrick Bayou Split Sample Task

Sediments were collected in August 2003 from six previously sampled locations (Parsons et al. 2004). Toxicity testing included the following:

- 10-day whole sediment toxicity tests conducted with amphipods (*L. plumulosus* and *Amplelisca abdita*) and mysids (*Americamysis bahia*)
- 7-day whole sediment tests conducted with clams (*Mercenaria mercenaria*), *A. abdita*, and *A. bahia*
- 96-hour sediment porewater toxicity tests conducted with *L. plumulosus*, *A. abdita*, and *A. bahia*

The data included in the BERA benthic toxicity model dataset include 51 samples (Figure 2-21) with co-located whole sediment bioassay data and surface sediment chemistry collected primarily in support of TMDL studies for Patrick Bayou (Parsons et al. 2002, 2004), as well as routine and special studies performed by TCEQ (Broach 2008). Of the surface sediment samples, 44 samples were collected within the Site, three samples were collected downstream of the Site in the HSC, and four samples were collected upstream of the Site boundary. Samples were collected between September 2000 and August 2006 and analyzed for metals, PAHs, SVOCs, and PCBs.

2.3.6.4 Benthic Community

Benthic community studies were completed by others in September 2000, April 2001, and August 2003. In September 2000, samples were collected by TNRCC from 19 locations within the Site. In April 2001, the Patrick Bayou TMDL Lead Organization (Parsons et al. 2002) collected samples at 18 of these locations. Again, in August 2003, the TMDL Lead Organization (Parsons et al. 2004) collected a limited dataset at sampling locations 9, 7, R, 6a, 4a, 3, and E.

2.3.7 Groundwater

Potential groundwater impacts to the Site have been evaluated through numerous independent investigations conducted at adjacent properties (Shell, Lubrizol, and Oxy) over the last several decades. TCEQ-approved corrective actions are underway at each facility that prevent unacceptable impacts to the Site (see Section 4.6). These corrective actions have resulted in mitigation of unacceptable impacts to the Site. Activities at each facility are summarized below.

2.3.7.1 Shell Deer Park

Groundwater monitoring and remediation activities are currently being conducted under Compliance Plan #CP-50099-001 issued by the TCEQ based on investigation activities dating back to the late 1980s. A Compliance Plan for the Site was first issued by the predecessor agency of the TCEQ in November 1988. The current Compliance Plan, issued in January 2011 (Shell 2011), describes groundwater monitoring and management of three plume management zones (PMZs) and one groundwater detection monitoring area. Semi-annual Compliance Plan Reports, submitted to the TCEQ in January and July of each year, supplement a facility-wide groundwater assessment, which is documented in the *Facility-Wide Affected Property Assessment Report* (APAR) submitted to the TCEQ in February 2012 (Shell 2012).

To date, on-site groundwater corrective action programs along the Site have included:

- Installation of a slurry wall east of the south wastewater treatment facility
- Operation of several groundwater extraction and treatment systems and nonaqueous-phase liquid (NAPL) recovery in several waste management areas (WMAs) located throughout the facility

Specifically, corrective action activities consist of pumping impacted groundwater from a series of active recovery wells located in WMAs, supplemented by periodic evacuations from specified wells using vacuum trucks and/or NAPL recovery using sorbent socks. In the southeast portion of the facility, Shell is operating a network of 30 recovery wells to reduce source area concentrations and mitigate groundwater discharges to the Site. These activities are being supplemented by periodic evacuation from three additional wells located near the Site. In the northeast portion of the facility, groundwater extraction from a network of three active recovery wells supplemented by periodic evacuations from six additional wells is being conducted to manage impacted groundwater in the vicinity of the Site.

On April 30, 2009, the Steering Committee for the Patrick Bayou Weight-of-Evidence (WOE) Evaluation (comprised of three members from the TCEQ and two members from Shell) met to review the findings of an evaluation conducted between 2005 and 2009 into the potential relationship, or lack thereof, of facility-specific chemicals of concern (COCs) present in groundwater beneath the Shell facility and the observed sediment toxicity in Patrick Bayou. At the outcome of that meeting, the Steering Committee determined that the results of the evaluation supported the conclusion that facility-specific COCs in groundwater at the Shell facility do not cause or contribute to sediment toxicity in Patrick Bayou.

Additional details regarding groundwater management at Shell Deer Park are discussed in Section 4.6.1.

2.3.7.2 The Lubrizol Corporation

Lubrizol has been conducting groundwater related investigation and mitigation activities since 2001 and more recently pursuant to Compliance Plan #CP-50077 (as updated in 2011), including:

- Monitoring an extensive network of 163 monitoring wells
- Operation of a small groundwater extraction system in accordance with the Compliance Plan (comprised of four recovery wells) to address a localized methanol release. Groundwater elevation data show a stable cone of depression with total plume capture
- Voluntary operation of 13 groundwater pumping wells at strategic locations along Patrick Bayou for general groundwater management and containment
- Intallation of a phytoremediation system (eucalyptus trees) to ensure shallow groundwater management and containment in areas where low permeability soils preclude efficient groundwater recovery (most trees are located adjacent to Patrick Bayou)
- Groundwater sampling and reporting
- Demonstration of ongoing natural attenuation processes
- APAR and Human Health/Ecological Risk Assessment submittals

2.3.7.3 OxyVinyls, LP

The Oxy facility groundwater system has been studied extensively since 1987, culminating in several TCEQ-approved corrective action controls and ongoing quarterly and/or semiannual monitoring by Oxy from 1992 through present. Remedial actions, some of which began in 1993, currently in place at the facility include the following:

- A groundwater monitoring program consisting of over 140 wells
- A gradient control system consisting of 28 vertical and three horizontal wells designed to recover impacted groundwater and free phase, which had recovered and treated over 140 million gallons of impacted groundwater as of 2007
- A 2,600 linear foot groundwater control wall
- Phytoremediation in areas where low permeability soils preclude efficient groundwater recovery

3 ENVIRONMENTAL SETTING

This section describes the natural and human-altered environmental setting of the Site. Physical characteristics of the Site include bathymetry, climate, sediment characteristics, and geology/hydrogeology. Human characteristics of the Site discussed here include Site structures, land use, and access to the Site. Finally, the ecological setting describes the available habitat and biota that may access the Site.

3.1 Bathymetry and Topography

A bank-to-bank bathymetric survey was conducted in 2005 by GBA for the Site and areas immediately upstream (south of SH 225) and downstream (within the proximal portions of the HSC). The results of this survey are shown in profile and plan views in Figure 3-1, Figure 3-2A, and Figure 3-2B, respectively. The upstream and upper portion of the Site (from the City of Deer Park WWTP outfall to the end of the gunite-lined channel) has a significantly higher hydraulic gradient (about 10 feet of elevation change over 5,000 linear feet) when compared to the middle and lower portions of the Site (less than 1 foot of elevation change over 8,000 linear feet).

The channel base elevation between Stations PB-037 and PB-080 (the downstream limit of the gunite-lined channel) is not generally deeper than -3 feet referenced to the North American Vertical Datum of 1988 (NAVD88). Bank slopes in this area are relatively flat, and transitions between the channel and shoal/deposition areas are poorly defined. Downstream of Station PB-037 to Station PB-028, the bank slopes are steepened slightly, with channel base elevations reaching -6 feet NAVD88. The channel widens downstream of Station PB-028 prior to its intersection with the HSC, and areas of shoaling/deposition and channel flow are more clearly defined. Near the two small islands in the lower portion of the Site (PB-017), the primary channel alignment is offset toward the east bank and transitions to the west bank of the Site. Channel base elevations between PB-028 and PB-017 range between -2 and -4 feet NAVD88. Downstream of PB-017, channel base elevations generally reach between -4 and -6 feet NAVD88. The channel base elevations at the downstream Site boundary range between -6 and -8 feet NAVD88.

Stream bank heights in areas with bulkheads and riprap are generally steep with top of bank elevations exceeding +9 feet NAVD88. Areas without bank modifications, which include much of the middle section of the Site, typically have low, sloping banks with bank elevations less than +6 feet NAVD88. Bank cover in areas without riprap or bulkheads is generally mowed grass with some low shrubs and bare earth. In many areas, industrial facilities and impervious surfaces such as parking lots and roads are located adjacent to the banks of the Site.

A U.S. Geological Survey (USGS) digital-rastergraphic image of the area surrounding the Site, which was obtained during 1999-2000, contained contour elevation data that were used to estimate the boundaries of the surrounding watershed and sub-basins within it. This information was developed to support the STM and details on the delineation can be found in the *Sediment Transport Modeling Report* (Anchor QEA 2012b). Figure 3-3 shows the results of the watershed and sub-basin delineations. The total area of the watershed is 2,775 acres, with sub-basins 1, 2, and 3 representing approximately 69 percent, 11 percent, and 20 percent of the total watershed area, respectively.

3.2 Land Cover

Spatial land cover data collected in 2002 were obtained from the H-GAC (H-GAC 2013) as part of the *Sediment Transport Modeling Report* (Anchor QEA 2012b) to help estimate the amount of runoff that could be expected during storm events from different parts of the watershed. The data were divided into eight categories: high intensity developed; low intensity developed; cultivated land; grassland; woody land; open water; wetland; and bare land (Figure 3-4). The Site is primarily surrounded by high intensity industrial-developed land along its entire length. There are some areas of bare or grass covered land bordering the downstream portion of the Site. These open areas are part of the Shell and Oxy facilities.

3.3 Soil Types

The spatial distribution of soil categories was determined through the State Soil Geographic Dataset to support the modeling effort. The soil groups for the watershed sub-basins are presented on Figure 3-5. The study area is primarily composed of hydrologic soil Group D, which has a high potential for runoff[15] (Anchor QEA 2012c). Group D soils are clay loam, silty clay loam, sandy clay, silty clay, or clay. They are characterized as having very low infiltration rates when thoroughly wetted and consist chiefly of clay soils with a high swelling potential, soils with a permanent high water table, soils with a claypan or clay layer at or near the surface, and shallow soils over nearly impervious material.

3.4 Man-made Structures

There are several man-made overwater structures at the Site (Figure 3-6), including eight elevated pipelines and three functional bridges. There are two crossings upstream of the East Fork Tributary, and several crossings are clustered at the transition between the gunite-lined channel and natural channel bottom (at the railroad crossing). Downstream of the confluence of the East Fork and Patrick Bayou, there is a collapsed bridge at approximately PB-057, and there is a functional bridge near the mouth of the Site, at Station PB-012. There are two bridges that span the East Fork a short distance upstream of the Site boundary.

3.5 Climate

The Texas Gulf Coast has a Modified Marine climate dominated primarily by onshore flow of tropical maritime air from the Gulf of Mexico. The onshore flow is modified by a decrease in moisture content from east to west and by intermittent seasonal intrusions of continental air. More precisely, the region encompassing the Site is classified as subtropical humid, reflecting the relatively higher moisture content of Gulf air close to the Texas coast. Average annual temperature is 69° F, with an average daily high of 79° F and an average daily low of 58° F. The hottest months are July and August with average daily high and low temperatures of 94° and 73° F, respectively. The average daily high and low temperature for the coolest month, January, is 62° and 41° F, respectively (Figure 3-7; SRCC 2005).

The average annual precipitation is 54 inches, with June typically experiencing the most precipitation, whereas February, March, and April are the driest months. Average monthly precipitation is approximately 4.5 inches (Figure 3-7; NCDC 2013).

[15] Soils are classified by the Natural Resource Conservation Service into four Hydrologic Soil Groups (A, B, C, D) based on the soil's runoff potential.

Tropical weather systems can have tremendous impacts on regional precipitation and hydrology along the Gulf Coast. Hurricane season runs from June 1 to November 30. Between 1851 and 2012, 64 hurricanes and 67 tropical storms have made landfall along the coast of Texas (NWS 2009; National Oceanic and Atmospheric Administration NOAA 2013). Tropical Storm Allison, which hit the Texas Gulf Coast on June 5 through 9, 2001, resulted in 5-day and 24-hour rainfall totals of 9.4 and 4.9 inches, respectively, in the City of Deer Park, resulting in significant flooding. Figure 3-8 provides a summary of daily rainfall data from 1993 through 2011 (Anchor QEA 2012b). This figure shows that it is not uncommon to have precipitation events that exceed 2 inches per day, and that on a 10-year basis, events that exceed 10 inches per day should be expected. These types of precipitation events produce wide variations in the volume of discharge into and out of the Site and have significant implications concerning variations in flow velocities and sediment transport.

3.6 Hydrology and Hydrodynamics

This section provides a brief summary of tidal characteristics, watershed precipitation and hydrology, and in-channel hydrodynamics. Water surface elevations in the study area are affected by a combination of the following processes: 1) tides generated in the Gulf of Mexico; 2) low-frequency storm events (e.g., hurricane storm surges); and 3) long-period waves propagating up and down the HSC.

Water surface elevation (WSE) data were obtained from NOAA tidal gauge stations to support the hydrodynamic and sediment transport modeling effort. As shown in Figure 3-9, the closest NOAA tidal gauge station to the Site is located at Battleship Texas State Park, near the confluence of the HSC and San Jacinto River, and another station is located about 8 miles downstream along the San Jacinto River at Morgans Point. No significant differences exist in WSE amplitude and phase between the two stations (Anchor QEA 2012b). Typically at Morgans Point, the range of diurnal tides is 1 to 2 feet, with the range of semi-diurnal tides being less than 1 foot. The difference between mean higher high water (MHHW) and mean lower low water (MLLW) is 1.3 feet at Morgans Point.[16]

[16] http://tidesandcurrents.noaa.gov/station_info.shtml?stn=8770613+Morgans+Point+,+TX

Base-flow discharge (i.e., freshwater inflow during periods with no precipitation) was estimated using flow rate data collected at stations PB-075 and EF-005 during October through December 2006 for the hydrodynamic model (Anchor QEA 2012b). For station PB-075 (i.e., main inflow), base-flow discharge ranges from about 1 to 100 cubic feet per second (cfs), with an average value of 28 cfs. For station EF-005 (i.e., East Fork), base-flow discharge is about a factor-of-ten less than the main inflow, with an average value of 2 cfs and a range of about 0.1 to 10 cfs.

Flow data were collected at several stations within the Site in October 2006 to provide data for calibration of the STM. The hydrograph for water surface elevation is shown on the top panel of Figure 3-10. The maximum total peak inflow of 5,900 cfs occurred on October 16 (return period of about 10 years), with discharge from the main inflow, East Fork, and direct runoff contributing 66 percent (3,900 cfs), 11 percent (650 cfs), and 23 percent (1,350 cfs), respectively, to the maximum total inflow. The average total inflow to the Site was 240 cfs during October 2006. As shown on Figure 3-10, high-flow events in the Site are flashy (characterized by short-term rapid increases followed by short-term rapid decreases) and typically occur over timescales of 6 to 24 hours.

3.7 Sediment Characteristics

This section focuses on the physical characteristics of bed and suspended sediments at the Site, including sediment depth, grain size distribution, and erodibility.

3.7.1 Soft Sediment Distribution

As discussed in Section 2.3.1.2, soft sediment thicknesses were measured throughout the Site and immediately upstream and downstream in 2005 to identify potential sediment deposition zones, (Anchor QEA 2006a). These softer sediment accumulations are likely associated with more recent deposition compared to the firmer substrate encountered at refusal. A map showing interpolated sediment thickness across the Site is provided in Figure 3-11. Similarly, soft sediment thicknesses were measured in the upstream areas of the Site (above PB-065) during the additional upstream source characterization effort performed in 2011 (Figure 3-12; Anchor QEA 2012b).

The observed thicknesses in the surveys ranged from less than 1 foot up to 12 feet. As expected because of the steeper hydraulic gradient, upstream portions of the Site (i.e., upstream of Station PB-080), including the gunite-lined channel, had little accumulated sediment.

Downstream of the gunite-lined channel, there are significant depositional areas (up to 8 feet thick) containing soft sediments between PB-045 and PB-050 that are likely the result of reduced current velocity associated with the widening channel below the East Fork combined by the bottlenecking of the channel (that restricts flow) caused by the bridge and utility crossing. There are other significant soft-sediment depositional areas south and north of the islands in the lower portion of the Site. The thickest accumulation (up to 12 feet) is associated with what appears to be a point bar type deposit of materials between PB-000 and PB-005 on the north bank after the Site makes its final turn toward the HSC.

3.7.2 Grain Size

Grain size distribution data from surface-layer (0-2 cm) samples collected at the Site during October 2006 were used to calculate average values of bed composition and effective particle diameter in the Site to support the *Sediment Transport Modeling Report* (Anchor QEA 2012b). Four particle size classes were used in the modeling effort to represent the major components of the sediment bed at the Site. The four classes are: 1) clay and silt with particle diameters less than 62 micrometers (μm); 2) fine sand (62 to 250 μm); 3) medium and coarse sand (250 to 2,000 μm); and 4) gravel (greater than 2,000 μm). The average values of bed content for classes 1, 2, 3, and 4 is 50 percent, 33 percent, 9 percent, and 8 percent, respectively. Sediment classes 2, 3, and 4 have median effective diameters of 130,630, and 3,210 μm, respectively. Grain size distribution data for surface-layer sediment were also analyzed to determine effective bed roughness (i.e., D_{90}) values. The average D_{90} of nine sediment samples collected at the Site is 230 μm.

The sediment bed within the Site is separated into two distinct types: 1) cohesive (i.e., muddy bed composed of a mixture of clay, silt, sand and organic matter); and 2) non-cohesive (i.e., sandy bed composed of sand and gravel, with small amounts of clay and silt). Sediment samples indicate that the bed is primarily composed of cohesive sediment, with non-cohesive sediment occurring in isolated, localized areas at the Site.

3.7.3 Erodibility

The locations of 12 Sedflume[17] cores collected and tested to evaluate sediment erosion properties are shown on Figure 3-13. Of particular interest in the data analysis is the spatial variability, both horizontally and vertically, of erosion rate parameters of Site sediments. A description of the erosion rate parameters and the Sedflume analysis can be found in Appendix B of the *Sediment Transport Modeling Report* (Anchor QEA 2012b). In the vertical direction, Sedflume core data were obtained from five discrete layers with the following depth intervals: 0 to 6, 6 to 11, 11 to 16, 16 to 21, and 21 to 26 cm. The following characteristics are observed with respect to vertical variability in erodibility: 1) sediments downstream of approximately PB-040 tend to have significant decreases in erodibility with increasing depth in the bed due to consolidation; and 2) sediments upstream of approximately PB-040 tend to exhibit variable erodibility in the vertical direction, with some cores having increasing erodibility with increasing depth (e.g., core SF-11). With respect to horizontal variations in the erodibility of sediment at the Site, the following insights are derived from the Sedflume analysis: 1) minimum erodibility occurs in core SF-6; 2) maximum erodibility occurs in core SF-11; 3) horizontal variability in erodibility is lowest in the top (0 to 6 cm) layer, with spatial variability tending to increase with depth in the sediment bed; and 4) no spatial patterns are evident in the horizontal plane. In addition, Sedflume data from twelve cores are not sufficient to use interpolation methods to develop a reliable horizontal distribution of erosion properties. Thus, it was assumed that the erosion parameters for a given depth interval are spatially constant in the horizontal plane for the purposes of the STM. The erosion parameters for the five layers in the bed are listed in Table 3-1.

Dry density was also measured during the Sedflume study of June 2007. The average value for dry density of the 12 cores was 0.77 grams per cubic centimeter (g/cm^3).

3.7.4 Suspended Sediments

TSS concentration data were collected at sampling stations in the main inflow (station PB-075) and East Fork (station EF-005). Flow rate data were collected concurrently at these two

[17] Sedflume cores are specialized sediment cores collected for the specific measurement of sediment erosion rates and critical shear stress.

stations, making it possible to construct sediment rating curves (i.e., TSS concentration as a function of flow rate: Figures 3-14 and 3-15). In general, different relationships between TSS concentration and flow rate occur during low- and high-flow conditions. Transition flow rates for the two flow regimes are 80 and 20 cfs for the main inflow and East Fork, respectively. At the main inflow, minimal correlation between TSS concentration and flow rate exists for both the low- and high-flow regimes (Figure 3-14). The average TSS concentration in the main inflow is 24 milligrams per liter (mg/L) for flow rates less than 80 cfs and 58 mg/L for flow rates greater than 80 cfs. At the East Fork, there is minimal correlation between TSS concentration and flow rate in the low-flow regime (Figure 3-15). The average TSS concentration when flow rates were 20 cfs or less is 32 mg/L. For the high-flow regime in the East Fork, TSS concentrations show a reasonable correlation with flow rate and were described with a best-fit equation. These boundary loadings produce average annual sediment loads from the main inflow and East Fork of 930 and 120 metric tons per year, respectively, for the 14-year period from 1993 through 2006.

Incoming sediment loads at the two HSC downstream boundaries were specified in the STM using TSS concentration data collected by the Galveston Bay National Estuary Program during the period from 1972 through 2005. Stations 11271 and 11264 are closest to the upstream and downstream HSC boundaries, respectively. Minimal correlation exists between local precipitation or tributary flow rate and TSS concentration measured at these two stations. The average TSS concentration at the HSC stations is 25 mg/L. Cumulative frequency distributions for the TSS concentration data collected at stations 11271 and 11264 are presented on Figure 3-16. The two distributions are similar, which indicates that there is no significant difference between TSS concentrations at these two HSC locations over long time periods.

3.8 Sediment Transport

The following sections discuss the sediment transport regime for the Site based on the STM. Sedimentation rates, stability, and loading were addressed by the STM simulations and are summarized below.

3.8.1 Net Sedimentation Rates

The NSRs at the Site were estimated using radioisotope data from sediment cores collected at the Site during October 2006 and November 2008 (Figure 3-17). An analysis of the lead-210 activity data from those cores was useful for estimating NSRs that are representative of the period from about 1980 to the present. Of the cores examined during the lead-210 age-dating analysis, only the cores collected at stations PB-022 and PB-048 during the October 2006 study (Anchor 2007b) and at stations PB-006, PB-016, PB-025, and PB-052 during the November 2008 study (Anchor QEA 2009b) produced NSR values. The other three cores were "unreadable", which means that the variability of the vertical profiles of lead-210 activity was too high to reliably estimate NSR in those cores. The estimated NSR values range between 0.15 cm/year and 2.5 cm/year, and the cores with higher NSR are located in the upstream portion of the Site (Figure 3-17).

The STM was calibrated to the lead-210 derived NSR. Spatial distribution of the predicted NSR at the Site is shown in Figure 3-18. The STM indicates that significant spatial variability in NSR exists at the Site, ranging from areas in dynamic equilibrium (i.e., NSR less than about 0.1 cm/year) to areas with relatively high net sedimentation (i.e., NSR greater than 1.5 cm/year). Most of the Site is net depositional over the 14-year period used to calibrate the STM, with the exception of some areas located between stations PB-025 and PB-036, and another area immediately downstream of station PB-012. Generally, NSR tends to decrease moving from the main inflow and East Fork toward the HSC. However, NSR tends to increase in the vicinity of the confluence of the Site with the HSC (i.e., downstream of station PB-012) due to the influence of sediment loading from the HSC.

3.8.2 Sediment Stability

The STM was used to simulate sediment transport processes at the Site during high-flow events. The results of these simulations were used to address specific questions about the effects of high-flow events on bed stability. A range of high-flow conditions, from 2- to 100-year events, were investigated, with the objective being to answer the following questions:

- What areas in the Site are depositional and what areas experience erosion during a high-flow event?
- In the areas that experience erosion, what is the potential depth of net erosion?

In addition, a sensitivity analysis was conducted to evaluate the effects of uncertainty in model inputs on model results.

Three 24-hour design storms, with return periods of 2-, 10-, and 100-years, were evaluated. Obtained from the Harris County Flood Control District, the precipitation magnitudes for these events are 4.5, 7.8, and 13.5 inches for the 2-, 10-, and 100-year events, respectively. For a given event, the precipitation magnitude was used as input to the watershed model. Output from the watershed model was transferred to the hydrodynamic model (i.e., freshwater inflow at the main inflow and East Fork boundaries), which was used to drive the STM to predict sediment erosion and deposition.

Spatial distributions of predicted net erosion depths during the 2-, 10-, and 100-year high-flow events are shown on Figures 3-19, 3-20, and 3-21, respectively. During the 2-year high-flow event, net erosion is predicted to occur in about 44 percent of the total bed area of the Site, with bed scour primarily in the sub-tidal zone (Figure 3-19). Erosion depths are less than 2 cm, with maximum net erosion depth of 1.7 cm occurring near station PB-036. During the 10-year high-flow event, most of the net erosion depths are predicted to be less than 2 cm, but there are some areas with erosion depths predicted to range between 2 and 5 cm (maximum scour depth of 4.5 cm). Net erosion is predicted to occur in about 52 percent of the total bed area of the Site for the 10-year event. During the 100-year high-flow event, net erosion is predicted to occur in approximately 65 percent of the total bed area. The majority of the predicted net erosion is less than 6 cm, with a small area between stations PB-006 and PB-016 experiencing predicted net erosion depths between 8 and 10 cm. Maximum net erosion within this area is predicted to be 9.4 cm.

3.8.3 Sediment Loading

The effect of deposition of sediment from external sources (i.e., sediment loading from main inflow, East Fork, and direct runoff) on changes in sediment composition of the mixing zone (0 to 10 cm) layer was used to estimate the rate of chemical attenuation in the sediment bed. The mixing zone layer corresponds to the surface layer in the sediment bed that is affected by bioturbation and other physical mixing processes, which tend to homogenize the physical and chemical properties of this surface layer. The STM was used to predict these rates by tracking sediment from two sources: 1) external loads (i.e., main inflow, East Fork, direct runoff); and 2) original bed sediment (i.e., bed sediment at the beginning of the 14-year simulation). The relative proportions of these two sources through time can be used to approximate chemical concentrations as well. Assuming an initial chemical concentration and continuous deposition with no erosion, the chemical concentration will decrease at an exponential rate towards a final condition commensurate with external loads.

At the beginning of the 14-year simulation, the composition of the mixing zone layer is 100 percent bed-source sediment, with no sediment from the external source. As the 14-year simulation progresses, external-source sediment is transported into the Site and is deposited in the mixing zone layer, which reduces the relative amount of bed-source sediment in that layer. The model tracks spatial and temporal changes in the relative amounts of sediment from the two sources over the course of the 14-year period that result from erosion, deposition, and transport processes within the Site. These temporal changes in bed-source sediment can be converted to an equivalent half-time (the time needed for a 50 percent replacement of bed-source sediment with external load sediment), the spatial distribution of which is shown on Figure 3-22. Predicted half-times are average values for the 14-year simulation period (i.e., 1993 through 2006). Model predictions indicate that approximately 30 percent of the total bed area within the Site has a half-time of less than 5 years and about 40 percent to 45 percent of the total bed area has a half-time of between 5 and 10 years (Figure 3-23). Approximately 10 percent of the Site bed area was predicted to have a half-time of 30 years or more.

The STM model can also be used to estimate the relative effects of the two sediment sources (i.e., external load and original bed) on the sediment mass balance over the course of the 14-year simulation. The results indicate that: 1) 55 percent to 60 percent of the external sediment load is deposited within the Site; 2) suspended sediment transport within the Site is dominated by the external load; and 3) less than 10 percent of the sediment load transported from the Site to the HSC is composed of sediment from the original bed.

3.8.4 Sediment Transport Modeling Conclusions

Results of the empirical and modeling analyses led to the following conclusions for sediment transport within the Site:

- As a whole, the Site is net depositional over annual time scales, with approximately 55 percent to 60 percent of the sediment load entering from the surrounding watershed being deposited within the Site.
- NSRs are spatially variable, with values ranging from less than 0.1 cm/year to more than 2 cm/year.
- Bed erosion is typically an episodic process that is most pronounced during high-flow events. During the 100-year high-flow event (i.e., event with 1 percent chance of being exceeded in a given year), net erosion occurs in approximately 65 percent of the total bed area and the majority of the net erosion is less than 6 cm. During the 2-year high-flow event (i.e., event with 50 percent chance of being exceeded in a given year), net erosion occurs in about 45 percent of the total bed area and erosion depths are less than 2 cm. Generally, erosion at the Site, even during high-flow events, only affects surface-layer sediments and is limited to bed depths that represent relatively recent deposition.
- The results indicate that for about 70 percent of the Site, the concentration of a COPC in the mixing zone layer will decrease by one-half of its current concentration in less than 10 years in areas assuming “clean” sediment input.

3.9 Geology and Hydrogeology

This section describes the regional and local geological and hydrogeological settings with respect to how groundwater may interact with the Site.

3.9.1 Regional

Patrick Bayou is located on the Brazos Deltaic Plain of the Western Gulf of Mexico physiographic province. Shallow soils in the area are deltaic, fluvial, and coastal interdeltaic deposits of Pleistocene age. The Beaumont Formation directly underlies the Site. This formation consists of interfingered fine sand and clays of varying thickness. The transitional nature of the formation materials often results in hydraulic communication between individual sand units, and makes lateral correlations of units over large areas difficult.

Groundwater within the Beaumont Formation is not used as a drinking water source in the area (Oxy 1998).

Up to 600 feet of similar lithologic units of Pleistocene age underlie the Beaumont Formation; however, there is not an apparent pathway for groundwater communication between the Beaumont Formation and these underlying materials. From youngest to oldest, the Pleistocene units include the Montgomery, Bentley, and Willis Formations. The Evangeline and Chicot Aquifers of these Pleistocene units are the primary sources of potable water in the Houston-Galveston area. The deeper Evangeline Aquifer provides most of the water used in the Houston-Pasadena area. The depth of this aquifer ranges between 550 to 2,500 feet below mean sea level (MSL) in the Deer Park area.

The Chicot Aquifer provides most of the water used in southeastern Harris County and in Galveston County. The Chicot Aquifer recharges where it crops out at the ground surface approximately 10 to 40 miles northwest of the Site along a 30 mile-wide band. The thick sections of overlying Beaumont Formation materials result in little or no recharge to the aquifer in the vicinity of the Site (Oxy 1998).

3.9.2 Local

Each of the facilities that border the Site has identified three water-bearing zones (WBZs) in the shallow hydrogeologic section. Summary descriptions of each zone are generally consistent with the description of the Beaumont Formation. As part of the PSCR, cross-sections were prepared depicting subsurface conditions (and the WBZs) under the Oxy and Lubrizol facilities on the east side of the Site, the gunite-lined channel, and the Shell facility on the west side of the Site (Figures 3-24, 3-25, and 3-26).

The hydrogeologic sections show the shallowest WBZ elevation is above the surface water elevation of the Site and that groundwater in this zone would likely discharge into the Site. This observation is also consistent with observed water levels in the shallow water-bearing zone at all three facilities. Figure 3-27 shows a potentiometric surface map for the shallowest WBZ near the Site. Although the water level measurements used to construct this map were taken under different programs and on different dates, the map is a helpful tool for interpreting groundwater flow directions in this unit and provides the following insights:

- There is an almost classic water table surface that generally follows surface topography.
- There are drainage divides on each side of the lower Site at the Shell and OxyVinyls facilities where groundwater flows toward the HSC or the Site on either side of the divide.
- There are several cones of depression on both sides of the Site that are associated with groundwater corrective measures pumping wells.
- There is a general increase in hydraulic gradient in areas near the Site.

The second water-bearing zone lies below the base of the channel at the Site, and does have the potential to directly discharge through sediments and into the surface water of the Site. In addition to the three water-bearing zones discussed above, OxyVinyls recognizes a fourth water-bearing zone from approximately 155 feet below ground surface (bgs). The lower unit is comprised of a confined, fine sand water-bearing unit that varies from 2.5 to 7 feet thick. This sand is underlain by more than 200 feet of clay with alternating sands to the depth of the potable water aquifer at approximately 350 feet.

3.10 Land Use and Ownership

Property ownership begins at the mean higher watermark adjacent to submerged lands in Texas. The Site is bounded primarily by industrial facilities; ownership includes Shell, Lubrizol, and Oxy (Figure 3-28). Land ownership along the East Fork Tributary includes Lubrizol, Oxy, Praxair, and Rohm and Haas Texas, Inc.

During development of the PSCR (Anchor 2006a), land use data were obtained from Texas Natural Resources Information System and modified using USGS orthoimagery (USGS 2002) based on Site knowledge. A more recent set of land use data was subsequently obtained from H-GAC (Merrick 2008) and is provided in Figure 3-29. The more recent land use data from H-GAC supports conclusions from the previous analysis and confirms the dominant land use surrounding the Site is industrial. The dominant land uses upstream of the watershed includes a mix of residential, commercial, and industrial.

According to 2010 census data (U.S. Census Bureau 2010), there are no residences within the Patrick Bayou watershed adjacent to the Site (i.e., north of SH 225). In the upstream watershed (south of SH 225), population densities are consistent with the residential, light industrial, commercial, and municipal character of the area (Figure 3-30).

3.11 Drinking Water Supply

The City of Deer Park gets surface water from the Trinity River via Lake Livingston. This water is purchased from the City of Houston through the Coastal Water Authority. Besides surface water, the City of Deer Park maintains three groundwater wells on standby. These wells could be used on an emergency basis if the raw water supply should be interrupted for any reason. These wells draw water from the Gulf Aquifer[18] (City of Deer Park 2013). This aquifer is isolated from overlying shallow aquifers and is not affected by potential shallow groundwater contamination (see Section 3.9.2).

A review of the Texas Water Development Board's Water Information Integration and Dissemination System[19] (includes Groundwater database and Submitted Drillers Reports database), TCEQ's Water Well Report Viewer[20], and TCEQ's Source Water Assessment database[21] identified several groundwater wells within ½ mile of the Site (Figure 3-31). With the exception of the wells identified in the Source Water Assessment database, all wells were identified as for industrial use, environmental monitoring, soil borings, or filled/plugged/destroyed. Of the 12 wells identified in the Source Water Assessment database, all are reported to be in the Gulf Aquifer.

3.12 Human Access and Use

Access and use of the Site is limited to authorized workers associated with adjacent facilities. Access to the Site by the public is restricted on the landside by physical controls (e.g., fencing) and security/surveillance controls implemented by the industrial facilities along the Site. Unauthorized access by the public (i.e., trespassers) could potentially occur but is

[18] Gulf Aquifer is a general term that includes the Chicot and Evangeline Aquifers (TWDB 2013).
[19] http://wiid.twdb.state.tx.us/index_apps.asp
[20] http://www.tceq.texas.gov/gis/waterwellview.html
[21] http://www.tceq.texas.gov/gis/swaview

generally considered unlikely (Anchor QEA 2011d). Given the long historical record of heavy industrial use, adjacent land use is not expected to change in the foreseeable future.

The Captain of the Port of Houston-Galveston has established security zones for certain areas within the Houston and Galveston area, which include the portion of the HSC that Patrick Bayou enters (USCG 2013). Recreational/unauthorized vessels are excluded from these areas, preventing or discouraging access to the Site through the HSC by recreational or unauthorized vessel traffic. Access to the majority of the Site by water is also blocked by the low bridge and pipe crossings near PB-012.

3.13 Habitat and Ecological Setting

This section describes the general types and quality of habitat present as they relate to species potentially accessing the Site. This information is largely summarized from the detail provided in the BERA Work Plan (Anchor QEA 2011a) and the PSCR (Anchor 2006a) prepared for the Site.

3.13.1 Open Water Habitat

The Site's open water system is characteristic of bayous of the coastal Gulf of Mexico, consisting of a tidally-influenced secondary stream with sluggish flow during typical conditions. The Site is tidally influenced downstream of SH 225. Tides in the HSC are generally weak and exhibit semi-diurnal and diurnal components. However, winds often disrupt the astronomical tidal cycles and may dominate short-term circulation patterns. The range of diurnal and semi-diurnal tides is generally between 0.5 and 2 feet; with the diurnal tidal range typically being greater than the semi-diurnal range (NOAA 2006). The tidal range at the Site is also affected by flow and wind. During low-flow and wind-driven low tide conditions, the intertidal zone may become dewatered for extended periods (e.g., several days).

3.13.1.1 Tidal Zones

Tidal zones were established based on the 2005 bathymetry data (Anchor 2006b) and long-term tidal range data from the nearest gauging station[22]. The Site was divided into three areas: 1) subtidal (less than 0.5 feet); 2) intertidal (greater than or equal to 0.5 feet to less than 1.5 feet); and 3) supratidal (greater than or equal to 1.5 feet). These elevations represent the mean lower low water (0.5 feet) and mean higher high water (1.5 feet) for the Site. Based on these tidal datums, tidal zone boundaries for the Site are displayed in Figure 3-32. The size of the intertidal habitat encompasses 1.6 hectares (10 percent of the Site). Subtidal zones (less than -0.6 feet NAVD88) encompass 13.3 hectares (82 percent of the Site). The remaining area is supratidal (greater than +1.5 feet NAVD88) and accounts for 1.3 hectares (8 percent of the Site).

Intertidal zones are made up of primarily natural substrate. The gunite-lined portion of the Site (upstream of Station PB-080) has considerable amounts of debris, including large pieces of concrete, covering much of the bottom. The natural substrate downstream of PB-080 is dominated by two primary types of habitat: mudflats and tidal marsh. Areas of tidal marsh are limited. A review of the National Wetland Inventory map did not identify any areas of emergent, shrub/scrub, or forested wetlands within the Site boundary (Anchor 2006a). Although a detailed habitat assessment/delineation for the Site has not been performed as part of the RI, observations made during an ecological checklist and Site visit (Anchor 2006a) indicated that isolated patches of fringe marsh are apparent, particularly in the vicinity of the confluence with the East Fork Tributary. The remaining intertidal habitat is dominated by mudflats characterized by unconsolidated, silty sediments. No naturally consolidated or rocky material is present; some occasional constructed (e.g., concrete riprap) material is present in the intertidal zone.

Habitat within the subtidal zone is mostly open channel, and stream velocities are expected to be relatively higher than the intertidal zone under most conditions. This zone lacks any

[22] These values were derived from the gauge datums for the NOAA/TCOON station located at Battleship Texas State Park (Station ID 8770743). Station information can be located at: http://tidesandcurrents.noaa.gov/data_menu.shtml?stn=8770743%20Battleship%20Texas%20State%20Park,%20TX&type=Datums.

significant submerged or emergent vegetation. Firm substrate for encrusting organisms is limited to absent.

3.13.2 Bank and Riparian Habitat

Riparian conditions are degraded but variable, and range from grass to shrub/scrub to trees, with most areas exhibiting grass and shrubs (Anchor 2006a). The two small islands near the HSC have trees, sloping banks, and shrubs. Natural banks are generally low and gradually sloping with extensive vegetative cover. Banks that have been modified with shoreline armoring are steep and high with varying amounts of vegetative cover.

3.13.3 Upland Habitat

As discussed in the previous sections, the Site setting is industrial with expanses of paved upland areas and structures adjacent to the Site. These modifications translate to an upland habitat that is primarily a built environment. Some open spaces exist in downstream areas of the Site near the HSC but are fragmented and not connected to other areas of open or forested habitat.

3.13.4 Biota

This section briefly summarizes the expected and/or observed biota at the Site based on the ecological setting and Site features. A detailed evaluation of biota that may be exposed to Site contaminants is provided in the BHHRA Work Plan (Anchor QEA 2011d) and BERA Work Plan (Anchor QEA 2011a).

3.13.4.1 Benthic Invertebrates

In terms of benthic habitats, there are two types of benthic areas in the open water of the Site, both of which would be suitable for invertebrate colonization: unconsolidated sediments (silt and mud) and developed shoreline (e.g., rock riprap). The physical stability of these habitats would be expected to vary according to different forces exerted by tidal and freshwater flow. These forces would vary spatially and temporally as well. Invertebrates that occur in these benthic habitats have a close association with sediment and have limited home ranges, and therefore, physical conditions would be expected to influence patchiness and stability of the invertebrate communities. Several investigations have documented and described the benthic invertebrate community at the Site (Parsons et al. 2002, 2004; Broach 2008). Polychaetes (e.g., *Laeonereis culveri* and *Amphicteis floridus)* constitute the majority of the benthic abundance and biomass. Other prevalent taxa include Oligochaetes, Chironomids, and to a lesser extent Malacostraca (e.g., *Amphipoda* and *Macrobrachium*).

3.13.4.2 Fish

Commonly observed species of fish in Segment 1006 of the HSC include Gulf menhaden, bay anchovy (*Anchoa mitchilli*), Atlantic croaker (*Micropogonias undulates*), spot (*Leiostomus xanthurus*), striped mullet, white mullet (*Mugil curema*), and hardhead catfish (*Arius felis*). Other common species observed in the upper HSC include Gulf killifish, inland silverside (*Menidia beryllina*), and sheepshead minnow. Blue crab, white shrimp, and brown shrimp are commonly observed shellfish species (Seiler et al. 1991).

Within the Site, species collected during RI studies are generally consistent with what would be expected in Texas tidal streams. For smaller size class fish (less than 15 cm), Gulf killifish, Gulf menhaden, Atlantic croaker, and striped mullet were commonly observed. For larger size class fish (greater than 30 cm), hardhead catfish were common. Commonly observed shellfish species included blue crab, white shrimp, and brown shrimp.

3.13.4.3 Reptiles and Amphibians

Given the potentially brackish nature of even upstream areas during low-flow/high-tide periods, it is unlikely that amphibians are able to establish a significant presence at the Site and would need to breed off-site. The most likely reptiles that may be present in the vicinity of the Site include snakes and turtles. Red-eared sliders (*Trachemys scripta elegans*), a common turtle in coastal Texas, have been observed at the Site (Anchor 2006a). One common snapping turtle (*Chelydra serpentina*) was observed as well.

3.13.4.4 Mammals

Due to the industrialized and disturbed nature of the upland areas surrounding the Site, habitat to support terrestrial mammals is limited. Species that may be present would most likely include species with limited ranges and urban-adapted species. These would include animals such as raccoon (*Procyon lotor*), muskrat (*Ondatra zibethicus*), nutria (*Myocastor coypus*), mice, and rats. They would be expected to occur on the banks of the shoreline, in the shallow water habitats, and in the limited adjacent vegetated areas. However, natural shoreline amenable to a high degree of mammal use is limited at the Site, as much of the shoreline is modified by riprap and other armoring. In addition, human activity within the surrounding industrial areas of the Site is common. Because of these factors, mammals that avoid human presence (e.g., mink) are not expected to be present.

3.13.4.5 Birds

Birds are the principal aquatic-dependent wildlife species expected to occur at the Site. Birds observed at the Site during a 2005 Site characterization includes shorebirds, songbirds, waterbirds, and ducks (Anchor 2006a). Given the developed nature of the upland areas surrounding the Site, species that do not tolerate human presence or disturbed habitat are unlikely to use the Site frequently. The shallow water of the Site does provide some foraging habitat for wading shorebirds. The two small islands near the HSC provide some roosting and perching habitat for colonial waterbirds. Frequently observed species at the Site include great blue heron (*Ardea herodias)*, double-crested cormorants (*Phalacrocorax auritus*), belted kingfisher (*Megaceryle alcyon*), and killdeer (*Charadrius vociferous*).

4 NATURE AND EXTENT OF CONTAMINATION

This section describes the nature and extent of contamination in Site media, building on information presented in previous sections. Site characterization data are presented sequentially for upstream sources, groundwater, sediment, surface water and suspended sediment, and fish/invertebrate tissue.

4.1 Indicator Chemicals

COIs are expected to be present at a Site based on a review of Site information. Numerous chemical and physical parameters were identified as COIs during the RI for the Site and were subsequently analyzed and detected in sampled media. An initial list of PCOPCs was identified through a risk-based screening evaluation of RI data. This list was further refined to identify COPCs that may pose a risk to human health or the environment. Finally, the baseline risk assessments were used to identify COCs representing the primary risk drivers for the Site. To facilitate a clear and practical presentation of the nature and distribution of contamination at the Site for the RI, an indicator chemical (IC) list was identified from the list of COCs to represent the nature and extent of the range of contaminants in Site media. The IC selected for the RI are media-specific and are based on the results of the baseline human health and ERAs (Anchor QEA 2012a, 2013a) and to a lesser extent on non-risk-based factors. ICs and their rationale for selection for each media are described below.

4.1.1 Sediment Indicator Chemicals

PCBs are the primary IC for surface and subsurface sediments. PCBs were identified as a COC in the BERA for wildlife and benthic invertebrates. PCBs were analyzed in sediments (and other media) as both Aroclors and congeners; however, during the RI, PCBs were analyzed and reported primarily as specific congeners. Both total PCB Aroclors and total PCB congeners are included in the following discussions of PCBs as an IC. The basis for the total PCB concentration (Aroclor or congener) is identified for clarity in the following sections as appropriate. Lead, total PAHs, and bis(2-ethylhexyl) phthalate (BEHP) were identified as sediment COCs for benthic invertebrates and were also selected as sediment ICs as well.

4.1.2 Porewater Indicator Chemicals

Most benthic invertebrates[23] are in direct contact with both sediment and porewater. Similar to surface sediments, total PCBs, total PAHs, lead, and BEHP were selected as ICs for porewater based on risks to benthic invertebrates.

4.1.3 Suspended Sediment Indicator Chemicals

Suspended sediments entering the Site from upstream act as a source of chemicals for sediments within the Site. As a result, total PCBs, total PAHs, lead, and BEHP were selected as ICs for suspended sediments. Suspended sediments represent potential upstream source contributions to the Site that may eventually become bed sediments. As a result, these chemicals are important with regard to sediment ICs and potential source control. Thus, they are included as suspended sediment IC.

4.1.4 Surface Water Indicator Chemicals

PCBs are the only IC identified for surface water. PCBs were the only COI to exceed risk-based screening levels in the BHHRA or BERA. Although the risk assessments did not identify any unacceptable risk to human and ecological receptors due to PCBs in surface water, USEPA expressed that exceedance of state and federal surface water quality standards due to PCBs is a concern. As a result, PCBs were selected as an IC for surface water.

4.1.5 Biota Indicator Chemicals

As described in Section 2, edible and whole body tissue samples were collected to support the human health and ERAs. Based on the outcome of the risk assessments, PCBs were selected as a COC due to ingestion of contaminated fish and shellfish tissue by wildlife receptors. As a result, PCBs in whole body tissue are considered the primary IC for biota. Total PCB congeners and PCB Toxic Equivalents (TEQs) are both included in the nature and extent discussions for PCBs. Total PCB congeners are included to allow cross media comparisons while PCB TEQs are included to provide a more appropriate risk-based presentation of PCBs in biota.

[23] Some tube dwelling benthic invertebrates may create burrows irrigated with surface water that may limit exposure to porewater.

For edible fish and shellfish tissue, PCBs are included in the nature and extent discussion. Although no edible tissue COCs were identified based on the BHHRA Report (Anchor QEA 2012c), PCBs were included as IC for biota due to the current TMDL project underway for the HSC. Similar to whole body tissue, PCBs are discussed as total PCB congeners and PCB TEQs.

4.1.6 Groundwater and Soils

Although several COCs have been identified within facility groundwater based on their independent groundwater-related investigations pursuant to the Texas Risk Reduction Program (TRRP) and Voluntary Cleanup Program (VCP) initiatives overseen by the TCEQ, no groundwater ICs were identified for the RI. As discussed later in Section 4.6, each of the three identified adjacent facilities manage their groundwater programs outside CERCLA and groundwater is not considered a source of contaminants to the Site based on these management activities.

4.2 Sediments

This section presents the results for the sediment sampling conducted as part of the RI. Sediment samples include surface sediment, subsurface sediment, and porewater.

4.2.1 Surface Sediment

Surface sediment samples from 66 locations within in Site were collected from 0 to up to 11 cm during the RI[24]. Samples from 14 stations were collected in 2006, 46 stations in 2009, and six stations in 2011. The distribution of sample locations is provided in Figure 2-12. All four ICs were included in 2006 and 2009 sediment sample analyses. The 2011 samples were analyzed for PCB Aroclors and PAHs because those are the primary ICs in the upstream area that was the focus of that investigation. A complete description of these sampling events is provided in Section 2.3.2.5. Results for surface sediment ICs are discussed below and are summarized in Table 4-1. A detailed data summary is provided in Table A-1 of Appendix A.

[24] Several samples have been collected during the RI at shallower intervals (e.g., 0 to 2 cm). Results from these shallow surface intervals are not discussed here. Results for these shallow intervals can be found in Anchor (2007a).

Total PCBs were detected in all 60 samples. The concentration of total PCB congeners in surface sediment ranges from 0.0109 milligrams per kilogram (mg/kg) (Station PB-077) to 124 mg/kg (PB-026). Peak values (greater than 50 mg/kg) are observed at PB-026, PB-032, and PB-053A (Figure 4-1). Spatially, the concentrations of total PCBs are generally less than 11 mg/kg downstream of PB-024. Upstream of PB-024, total PCBs generally exceed 5 mg/kg. Lower values (less than 3.3 mg/kg) are observed near the confluence with the East Fork Tributary (PB-065) and in the upstream portion of the Site from PB-074 to PB-101A, with the exception of Station PB-081, which had a reported concentration of 21.8 mg/kg.

Total PAHs were detected in all samples (66 samples were analyzed for PAHs). The concentration of total PAHs in surface sediment ranges from 0.0164 mg/kg (PB-077) to 1,307 mg/kg (PB-081). Peak values (greater than 100 mg/kg) are observed at PB-009A, PB-026, PB-032, PB-053A, PB-081.1, and PB-081 (Figure 4-2). Spatially, most of the Site surface sediment values are between 7 and 50 mg/kg. Lower values (less than 7 mg/kg) are observed in the upper gunite-lined channel (above PB-090), near PB-074 and PB-077, PB-028, PB-048, and at the mouth of the East Fork Tributary (EF-001).

BEHP was detected in 55 of 60 samples. The concentration of BEHP in surface sediment ranges from 0.132 mg/kg (PB-101) to 11.8 (PB-007.1), as shown in Figure 4-3. Peak detected values (greater than 2.5 mg/kg) are observed at PB-007.1, PB-001.1, PB-037, PB-048, and PB-032. Although peak values of BEHP occur downstream of PB-048, no strong gradient in concentration is apparent within the Site. Lowest detected values are observed in the gunite-lined channel and at stations PB-064 and PB-073.

Lead was detected in 60 of 60 samples. The concentration of lead in surface sediment ranges from 9.72 (PB-064) to 335 mg/kg (PB-081; Figure 4-4). Peak values (greater than 200 mg/kg) are located across the Site at stations at PB-081, PB-036, PB-018, PB-011). Most values are less than 100 mg/kg. No strong gradient in concentration of lead is observed across the Site.

4.2.1.1 Upstream Sediment

This section presents the results for sediment ICs in areas upstream of the Site. The concentrations of ICs in surface sediments upstream of the Site are summarized in Table 4-2 and presented in detail in Table A-2 of Appendix A[25]. Sample locations are identified in Figure 2-11.

PCBs were only analyzed in samples collected from the culverts under SH 225 (PB-119.1 through PB-119.5). In sediment from the culverts, 196 of 209 individual PCB congeners were detected at least once (Table A-2). Total PCB congener concentrations ranged from 0.00838 mg/kg (PB-119.3) to 0.0174 mg/kg (PB-119.5).

The concentration of total PAHs in surface sediments upstream of the Site boundary ranged from 0.473 mg/kg (EF-008) to 51.5 mg/kg (PB-119.5). Concentrations of total PAHs were consistently higher in the samples collected from the culverts under SH 225 (range of 13.1 to 51.5 mg/kg) than other samples collected upstream of the Site (range of 0.473 to 8.9 mg/ kg).

Lead was detected in all sediment samples collected upstream of the Site boundary (Table 4-2). Concentrations ranged from 7.29 mg/kg (EF-008) to 201 mg/kg (PB-119; Table A-2). With the exception of Station PB-119, Station PB-119.4 and Station SE-002, all samples had lead concentrations less than 50 mg/kg.

4.2.2 Subsurface Sediments

Subsurface samples, defined as samples collected from depth intervals greater than 11 cm, were collected at 12 locations (Figure 4-5). All samples were analyzed for all sediment ICs. The distribution of total PCBs[26] total PAHs, BEHP, and lead are shown in Figures 4-6 through Figure 4-9. Detailed results are given in Table A-3 of Appendix A.

PCBs were detected in 79 of 88 samples. Stations PB-057, PB-048, and PB-042 have the highest subsurface maximum values at 476, 239, and 295 mg/kg, respectively. Subsurface total PCBs continue to decrease downstream of PB-057 to PB-003 which has a subsurface maximum of 7.3 mg/kg. Upstream of PB-057, subsurface values do not exceed 87 mg/kg. It should be noted that the depth of soft sediments in four of the five cores collected upstream of PB-057 did not exceed 85 cm bgs. Subsurface maximum values for most cores are between

[25] BEHP was not analyzed in sediment upstream of the Site.
[26] Only PCB Aroclors were analyzed in subsurface sediments.

50 and 80 cm bgs. With few exceptions, the lowest concentrations of total PCBs are observed in sample intervals near the contact with the Beaumont Formation.

PAHs were detected in all 88 samples and followed a distribution similar to total PCBs in subsurface sediment. Stations PB-057, PB-048, and PB-042 have the highest subsurface maximum values at 1,766, 1,263, and 816 mg/kg, respectively. Subsurface maximum values continue to decrease downstream to PB-003, which has a maximum subsurface value of 34.9 mg/kg. Upstream of PB-057, subsurface values do not exceed 53 mg/kg. It should be noted that the depth of soft sediments in four of the five cores collected upstream of PB-057 does not exceed 85 cm bgs. Maximum concentrations of PAHs in subsurface sediment for most cores are between 80 and 120 cm bgs. With few exceptions, the lowest concentrations of total PAHs are observed in sample intervals near the contact with the Beaumont Formation.

BEHP was detected in 59 of 88 samples. Increases in concentration with depth were generally not observed. Detection limits were frequently higher in deeper interval samples primarily due to matrix interferences requiring significant dilutions prior to analysis. The maximum detected concentration is located at EF-001 (48 mg/kg) between 131 and 161 cm. The next highest detected subsurface concentration is 15 mg/kg. Subsurface maximum values do not show any apparent trend moving laterally through the Site.

Lead was detected in 88 of 88 samples ranging in concentration between 11 and 840 mg/kg. Most stations demonstrate generally increasing concentration with depth. Subsurface maximum values show an apparent increasing trend moving upstream to station PB-057. The maximum detected value upstream of PB-057 is 104 mg/kg. With few exceptions, the lowest concentrations of lead are observed in sample intervals near the contact with the Beaumont Formation.

4.2.3 Porewater

Porewater was collected from ten locations within the Site boundary (Figure 2-13)[27]. Total PCBs, total PAHs, lead, and BEHP were selected as ICs for porewater. Figures 4-10, 4-11,

[27] See Section 2.3.3 for a complete description of the porewater sample collection.

and 4-12 present the results for total PCB congeners, total PAHs, and BEHP by location, respectively. Lead was not detected in any of the porewater samples. Results are presented in summary in Table 4-3 and in detail in Table A-4 of Appendix A.

Total PCBs were detected in all ten samples. Station PB-036 has the highest detected concentration of total PCB congeners with a reported concentration of 7,110 micrograms per liter (μg/L). The minimum concentration of 1.56 μg/L is reported at Station PB-006A. All samples except for the one collected at Station PB-036 have reported detected concentrations less than 35 μg/L.

Total PAHs were detected in all ten samples. Again, the maximum concentration of total PAHs is reported at Station PB-036 (18,320 μg/L), and is significantly higher than all other samples. The lowest concentration of PAHs in porewater, 1.87 μg/L, was reported at Station PB-006A. With the exception of Station PB-024, which has a total PAH concentration of 8,491 μg/L, all other stations have reported detected concentrations at 45 μg/L or less.

BEHP was detected in all ten samples. The maximum concentrations of BEHP are reported at Stations PB-036 (180 μg/L) and PB-046 (140 μg/L). The minimum concentration of 1 μg/L is reported at Station PB-006A. With the exception of Station PB-024, which has a concentration of 84 μg/L, all other stations have reported detected concentrations of BEHP less than 50 μg/L.

4.3 Surface Water

Surface water was collected during two sampling events. Twenty-two samples were collected from eight stations from outside and within the Site boundary in 2009 (Figure 2-15). In 2009, surface water samples were analyzed for several COIs. In 2011, PCBs were the only COPC included in the surface water sample chemical analysis. During this investigation four samples were collected from within the Site boundary in 2011 (Figure 2-15)[28]. Results for PCBs in surface water are summarized in Table 4-4; complete results are provided in Table A-5 of Appendix A.

[28] A complete description of these sampling events is provided in Section 2.3.5.2.

Total PCBs were detected in all samples for both the 2009 and 2011 sampling events. For the 2009 sampling event, the highest concentration of total PCBs (0.431 μg/L) for the low-tide sampling event was reported at Station PB-059A (Figure 4-13). The highest concentration of total PCBs for the mid-tide sampling event was reported at Station PB-031 (0.234 μg/L). For the 2011 sampling event, the highest concentration of total PCB congeners is reported at Station PB-080 (0.143 μg/L), and the farthest up-stream station, Station PB-101C, has the lowest total PCB congener concentration (0.00565 μg/L).

4.4 Suspended Sediment

As described in Section 2.3.4, suspended particulate material was sampled via sediment traps at the Site in 2008; six samples were analyzed from station PB-077 and five samples were analyzed from station EF-001 (Figure 2-14). Results are summarized in Table 4-5; complete results are provided in Table A-6 of Appendix A.

The concentrations of total PCB congeners in the six samples collected at Station PB-077 ranged from 0.17 to 3.7 mg/kg (Figure 4-14). The highest concentrations were reported from samples collected in October, December, and January.

The concentrations of total PCB congeners in the five samples collected at Station EF-001 ranged between 0.05 and 1.1 mg/kg (Figure 4-14). The highest total PCB congener concentration was reported in the October sample (1.1 mg/kg).

The concentrations of total PAHs in the six samples collected at Station PB-077 ranged from 5.0 to 11.5 mg/kg (Figure 4-15). The highest concentration was reported in the September sample (11.5 mg/kg).

The concentrations of total PAHs in the five samples collected at Station EF-001 ranged from 0.93 to 15.9 mg/kg (Figure 4-15). The highest concentration was reported in the December sample (15.9 mg/kg).

The concentrations of BEHP in the six samples collected at Station PB-077 ranged from 1,200 to 2,700 micrograms per kilogram (μg/kg) (Figure 4-16). The highest concentration was reported in the December sample (2,700 μg/kg).

The concentrations of BEHP in the five samples collected at Station EF-001 ranged from 170 to 580 μg/kg (Figure 4-16). The highest concentration was reported in the April sample (580 μg/kg).

The concentrations of lead in the six samples collected at Station PB-077 ranged from 30.7 50.2 mg/kg (Figure 4-17). The highest concentration was reported in the October sample (50.2 mg/kg).

The concentrations of lead in the five samples collected at Station EF-001 ranged from 22.9 to 38.8 mg/kg (Figure 4-17). The highest concentration was reported in the October sample (38.8 mg/kg).

4.5 Tissue

Nature and extent of contaminants in biota tissue are discussed for selected ICs previously identified in Section 4.1.5. The discussion is divided into two general categories—edible tissue and whole body—reflecting differences in the collection and processing of biota samples for human health and ERA, respectively.

4.5.1 Edible Tissue

Edible tissue includes biota samples collected as fish fillet and shellfish claw and carapace meat. These samples were collected to support the BHHRA (Anchor QEA 2012c). They include 20 blue crab edible tissue samples and 30 hardhead catfish fillet samples (see Figure 2-19).

PCBs were analyzed as congeners in all samples. Results are presented as total PCB congeners and TEQs based on the mammalian Toxicity Equivalency Factors (TEFs) of Van den Berg et al. (2006)[29]. Site maps showing shellfish and fish fillet sample locations and $TEQ_{mammalian}$ concentrations are provided in Figure 4-18 and Figure 4-19, respectively. Table 4-6 summarizes these results and Table A-7 in Appendix A provides detailed results.

For shellfish edible tissue, PCBs were detected in every sample. There were 197 PCB congeners detected in at least one sample, and 133 PCB congeners were detected in all 20 samples. Concentrations of total PCB congeners ranged from 19.6 to 377 µg/kg. The average concentration of total PCB congeners was 112 µg/kg. Total PCB $TEQ_{mammalian}$ ranged from 0.34 to 8.07 nanograms per kilogram (ng/kg). The average PCB $TEQ_{mammalian}$ was 3.18 ng/kg. For blue crab, no concentration-distance trend, as total or $TEQ_{mammalian}$, is evident (Figure 4-18).

PCBs were detected in all hardhead catfish fillet samples. Concentrations of total PCB congeners ranged from 187 to 5,360 µg/kg. The average concentration of total PCB congeners was 1,440 µg/kg. Total PCB $TEQ_{mammalian}$ ranged from 3.3 to 85.6 ng/kg. The average PCB $TEQ_{mammalian}$ was 24.6 ng/kg. For hardhead catfish, no concentration-distance trend in PCBs, total or $TEQ_{mammalian}$, is evident.

A box plot showing the distribution of total PCBs and PCB $TEQ_{mammalian}$ in edible tissue is provided in Figure 4-20. This figure illustrates that the distribution of values for total PCB congeners was slightly wider for shellfish than for fish, and that, overall, both PCB congeners and PCB $TEQ_{mammalian}$ were higher for fish than for shellfish.

4.5.2 Whole Body Tissue

A recent investigation conducted at the Site measured chemical concentrations in tissue of shellfish and fish for the purposes of evaluating risk to ecological receptors (Anchor QEA 2012c). A total of 83 samples from locations within the Site (Figures 2-17 and 2-18) were analyzed as part of this investigation. These samples included 33 shellfish samples and 50 fish samples. Four different shellfish species were collected and analyzed. These included blue crab, brown shrimp, oyster, and white shrimp. Blue crab and shrimp were analyzed in two different size classes. For these animals, Size Class A was comprised of animals ranging

[29] Calculation methodologies are described in the BHHRA Work Plan (Anchor QEA 2011d).

in length from 2.5 to 7.5 cm, and Size Class B contained animals from 7.5 to 13 cm. Five different fish species were collected and analyzed. These included Gulf killifish, Gulf menhaden, pinfish, sand seatrout, and striped mullet.

ICs identified for ecological risk in shellfish and fish are PCBs (total as well as TEQ_{avian} and $TEQ_{mammalian}$). The following sections provide descriptions of tissue data for shellfish and fish. Table 4-7 summarizes these results and Appendix A-8 provides detailed results.

4.5.2.1 Shellfish

For shellfish, the highest average PCB TEQs for both avian and mammal predators were reported in blue crab samples (782.9 [TEQ_{avian}] and 49.2 [$TEQ_{mammalian}$] ng/kg). For blue crabs in Size Class A, 192 PCB congeners were detected in at least one sample. A total of 125 congeners were detected in all 18 samples. Total PCB TEQs ranged from 97.6 to 783 ng/kg for PCB TEQ_{avian} and from 8.35 to 49.2 ng/kg for PCB $TEQ_{mammalian}$. The average PCB TEQ_{avian} was 362 ng/kg and average PCB $TEQ_{mammalian}$ was 24.8 ng/kg. Results from blue crabs in Size Class B showed 185 PCB congeners were detected in at least one sample. A total of 161 congeners were detected in all three samples. Total PCB TEQs ranged from 434 to 509 ng/kg for PCB TEQ_{avian} and from 30.8 to 43.1 ng/kg for PCB $TEQ_{mammalian}$. The average PCB TEQ_{avian} was 476 ng/kg and the average PCB $TEQ_{mammalian}$ was 35.6 ng/kg. In order to depict potential spatial relationships of concentrations along the Site, total PCB congeners, as well as PCB TEQ results were graphed with scatterplots showing results values versus distance from the mouth of the Site at its confluence with the HSC.

For brown shrimp, all specimens were from Size Class B, and results showed that 199 PCB congeners were detected in at least one sample. A total of 161 congeners were detected in all eight samples. Total PCB TEQs ranged from 370 to 695 ng/kg for PCB TEQ_{avian} and from 8.2 to 41.2 ng/kg for PCB $TEQ_{mammalian}$. The average PCB TEQ_{avian} was 533 ng/kg and the average PCB $TEQ_{mammalian}$ was 24.8 ng/kg. For the one white shrimp specimen from Size Class A, 167 PCB congeners were detected, and the total PCB TEQ_{avian} was 277 ng/kg and the total PCB $TEQ_{mammalian}$ was 18.1 ng/kg. In the two white shrimp from Size Class B, 183 PCB congeners were detected in at least one sample. A total of 177 congeners were detected in both samples. Total PCB TEQs ranged from 177 to 312 ng/kg for PCB TEQ_{avian} and from 9.3 to

16.7 ng/kg for PCB $TEQ_{mammalian}$. The average PCB TEQ_{avian} for both samples was 245 ng/kg and the average PCB $TEQ_{mammalian}$ was 13.0 ng/kg.

In the oyster sample, 188 PCB congeners were detected. Total PCB TEQs were 361 ng/kg for PCB TEQ_{avian} and 20.7 ng/kg for PCB $TEQ_{mammalian}$. The oyster result value relative to the distance from mouth of the Site is shown on the scatterplots for shrimp.

Spatial representation for shellfish PCB results, including TEQ values, is depicted in scatterplots and maps on Figures 4-21, 4-22, and 4-23. In general highest total PCB and PCB TEQ values for shellfish were observed between 2,000 and 8,000 feet from the HSC (i.e., PB-020 to PB-080). The distribution of these data can be viewed in boxplots to visualize result value distributions among species in Figure 4-24 through 4-26. Although apparent differences are observed between shellfish species, it is difficult to judge whether these differences are due to location or other factors (e.g., diet, age, etc.).

4.5.2.2 Fish

PCB concentrations were measured in Gulf killifish, Gulf menhaden, pinfish, sand seatrout, and striped mullet. The highest average PCB TEQs for both avian and mammal predators were reported in Gulf killifish samples (1,173 [TEQ_{avian}] and 137 [$TEQ_{mammalian}$] ng/kg).

For Gulf killifish, 204 PCB congeners were detected in at least one sample. A total of 147 congeners were detected in all samples. Total PCB TEQs ranged from 271to 1,173 ng/kg for PCB TEQ_{avian} and from 15.6 to 137 ng/kg for PCB $TEQ_{mammalian}$. The average PCB TEQ_{avian} was 795 ng/kg and average PCB $TEQ_{mammalian}$ was 77.4 ng/kg. In order to depict potential spatial relationships of concentrations along the Site, total PCB congeners, as well as PCB TEQ results, were graphed with scatterplots showing results values versus distance from the mouth of the Site at its confluence with the HSC. For Gulf killifish, as shown in the scatterplots and maps in Figures 4-27, 4-28, and 4-29, a general cluster of higher PCB result values and TEQs is visible near stations PB-050 to PB-070 as opposed to either the mouth or the upstream end of the Site.

In Gulf menhaden, 205 PCB congeners were detected in at least one sample. A total of 161 congeners were detected in all samples. Total PCB TEQs ranged from 197 to 789 ng/kg for PCB TEQ_{avian} and from 12.9 to 46.6 ng/kg for PCB $TEQ_{mammalian}$. The average PCB TEQ_{avian} was 449 ng/kg and average PCB $TEQ_{mammalian}$ was 31.2 ng/kg. Spatial representation for menhaden PCB results, including TEQ values, is depicted in scatterplots in Figures 4-30, 4-31, and 4-32. A general trend of increasing concentration of PCB result values and TEQs is visible from the mouth of the Site toward the upstream portions of the Site.

For pinfish, 197 PCB congeners were detected in at least one sample. A total of 168 congeners were detected in all pinfish samples. Total PCB TEQs ranged from 89.6 to 148 ng/kg for PCB TEQ_{avian} and from 24.0 to 51.4 ng/kg for PCB $TEQ_{mammalian}$. The average PCB TEQ_{avian} was 121 ng/kg and average PCB $TEQ_{mammalian}$ was 36.2 ng/kg.

For sand seatrout, 196 PCB congeners were detected in at least one sample. A total of 181 congeners were detected in all sand seatrout samples. Total PCB TEQs ranged from 77.5 to 188 ng/kg for PCB TEQ_{avian} and from 3.63 to 25.9 ng/kg for PCB $TEQ_{mammalian}$. The average PCB TEQ_{avian} for both samples was 133 ng/kg and average PCB $TEQ_{mammalian}$ was 14.8 ng/kg.

Striped mullet results showed that 202 PCB congeners were detected in at least one sample. A total of 178 congeners were detected in all striped mullet samples. Total PCB TEQs ranged from 104 to 789 ng/kg for PCB TEQ_{avian} and from 4.26 to 51.5 ng/kg for PCB $TEQ_{mammalian}$. The average PCB TEQ_{avian} for both samples was 356 ng/kg and average PCB $TEQ_{mammalian}$ was 21.6 ng/kg. Spatial representation for pinfish, sand seatrout, and striped mullet PCB results, including TEQ values, is depicted in scatterplots in Figures 4-33, 4-34, and 4-35. A slight trend of increasing concentration of PCB result values and TEQs is visible from the mouth of the Site toward the upstream portions of the Site.

The distribution of these data can be viewed in boxplots to visualize result value distributions among species. Figure 4-24 shows distributions of total PCB congeners; Figure 4-25 shows PCB TEQ_{avian}; and Figure 4-26 shows PCB $TEQ_{mammalian}$. These plots show similar and lower total PCB congener concentrations and TEQ_{avian} values among Gulf menhaden, pinfish, sand seatrout, and striped mullet as compared to Gulf killifish. $TEQ_{mammalian}$ values varied among species, but Gulf killifish values were generally higher than other species.

4.6 Groundwater

This section provides a summary the nature and extent of groundwater contamination near the Site, evaluated within the context of relevant groundwater-related activities that have been conducted at each facility adjacent to the Site.

As discussed previously, adjacent facilities—Shell, Lubrizol, and Oxy—have conducted detailed groundwater-related investigations pursuant to the TRRP and VCP initiatives overseen by the TCEQ. The focus of several of those investigations was to evaluate and quantify the potential for soil and groundwater from the facilities to impact sediment and surface water within the Site. It should be noted that potential groundwater impacts to sediments or surface water at the Site have not been identified in any of the available work conducted by these facilities or work conducted by the JDG.

4.6.1 Shell Deer Park Facility

Groundwater impacts at the Shell Deer Park property consist generally of dissolved chlorinated hydrocarbons, dissolved petroleum hydrocarbons, light nonaqueous-phase liquid (LNAPL), and dense nonaqueous-phase liquid (DNAPL) found in various areas of the Site. Under Compliance Plan #CP-50099-001 issued by TCEQ, Shell has been operating an extensive groundwater monitoring and corrective action program consisting of three PMZs, semiannual groundwater sampling and reporting, a slurry wall, several total fluids recovery systems, periodic total fluid recovery in certain wells, and NAPL recovery using sorbent socks in certain wells (Shell 2012; Figure 4-36).

Groundwater impacts have been identified in three of the four WBZs beneath Shell Deer Park, with the deepest of these three WBZs present between approximately -45 and -110 feet MSL (Figure 4-37). The upper two of the four WBZs have hydraulic connectivity with the Site, with the deeper of these two WBZs found between approximately -15 and -45 feet MSL. LNAPL and DNAPL have been found in the upper two WBZs. The primary contaminants in these two WBZs include:

- 1,1-Dichloroethane
- 1,2-Dichloroethane
- 1,2-Dichloropropane

- 1,2,3-Trichloropropane
- 2-Butanone (Methyl Ethyl Ketone)
- 2,3-Dichlorobutane
- 4-Methyl-2-Pentanone (Methyl Isobutyl Ketone)
- Acetone
- Benzene
- Isopropylbenzene (Cumene)
- Phenol
- Tert-Butyl Alcohol
- Vinyl chloride

None of these contaminants correlate with COCs within the Site.

As discussed in Section 2.3.7.1, the Steering Committee for the Patrick Bayou WOE Evaluation (comprised of three members from the TCEQ and two members from Shell) determined in April 2009 that facility-specific COCs in groundwater at the Shell facility do not cause or contribute to sediment toxicity in Patrick Bayou.

4.6.2 The Lubrizol Corporation

The list of pertinent facility-specific COCs at the Lubrizol Site (screened using accepted TCEQ protocol) consists of alcohols, metals, PCBs, and VOCs (including chlorinated hydrocarbons and BTEX, which is comprised of benzene, toluene, ethylbenzene, and xylene). Lubrizol has been conducting groundwater related investigations and mitigation activities pursuant to Compliance Plan #CP-50077 (as updated in 2011), including the installation of an extensive network of monitoring wells, the operation of a small methanol groundwater recovery system (currently comprised of four recovery wells to address a previous methanol release), and groundwater sampling and reporting. Groundwater remediation under the Lubrizol Compliance Plan is limited to one small area on the western Lubrizol boundary. However, in addition to the Compliance Plan requirements Lubrizol is also conducting voluntary groundwater containment and remediation efforts along Patrick Bayou. This work includes operation of a voluntary groundwater recovery system (consisting of 13 strategically-located wells along Patrick Bayou) and a phytoremediation program (eucalyptus trees) in areas where low permeability soils preclude efficient groundwater recovery; the majority being located along the property boundary adjacent to Patrick Bayou (Lubrizol 2011; Figure 4-38).

Four WBZs have been identified on the Lubrizol site, with the upper three WBZs exhibiting groundwater impacts above relevant criteria. However, TCEQ has agreed that there is no connection of the third zone to Patrick Bayou and that this zone is separated from the overlying zone by a thick impermeable clay. Consequently, only the upper two WBZs (to an approximate depth of -20 feet MSL) might have some hydraulic connectivity with the Site (with the second zone exhibiting very limited, in any, connectivity). Facility-specific COCs present in these two WBZs in common with the Site consist of the following:

- 1,2-Dichloroethane
- 1,1-Dichloroethene
- *cis*-1,2-Dichloroethene
- *trans*-1,2-Dichloroethene
- 1,2-Dichloropropane
- 1,1,2-Trichloroethane
- 4-Methyl-2-pentanol
- 4-Methylphenol/3-Methylphenol
- Acetone (2-Propanone)
- Benzene
- Ethylbenzene
- Mercury
- Methylene chloride
- PCB (total)
- Tetrachloroethene
- Toluene
- Trichloroethene
- Vinyl chloride
- Xylenes (total)

4.6.3 OxyVinyls Deer Park Facility

The facility-specific COCs at the OxyVinyls Deer Park facility consist of chlorinated hydrocarbons, primarily in dissolved form with trace amounts of associated DNAPL. OxyVinyls maintains a site-wide groundwater monitoring and recovery system, which has been operational since 1993 (Weston 2007). The system currently includes both vertical and horizontal recovery wells in pertinent locations and a gradient control (i.e., slurry) wall along a portion of the Site (Figure 4-39; Weston 2007). OxyVinyls also uses sheetpile and phytoremediation (eucalyptus trees) in certain areas of their facility to limit the amount of infiltration and evapo-transpire groundwater behind the slurry wall.

Four WBZs have been identified at the OxyVinyls facility (the deepest present to at least -100 feet MSL), with the upper two WBZs exhibiting impacts to groundwater, as well as potential hydraulic communication with the Site. The lower of the two upper WBZs is present to a depth of approximately -60 feet MSL. Facility-specific COCs present in the upper two WBZs include the following:

- 1,1-Dichloroethane
- 1,2-Dichloroethane
- 1,1-Dichloroethene
- 1,2-Dichloroethene
- 1,1,1-Trichloroethane
- 1,1,2-Trichloroethane
- Tetrachloroethene
- Trichloroethene
- Vinyl chloride

None of these contaminants correlate with COCs within the Site.

4.6.4 Summary of Groundwater Sources

As discussed previously in the PSCR (Anchor 2006a), each facility carried out independent groundwater investigations in parallel with investigations in the Site under their ongoing TCEQ-regulated TRRP or VCP program. Furthermore, corrective actions have been and continue to be in place and functioning at each adjacent facility to prevent groundwater interaction with the Site. The interaction between potentially contaminated groundwater and Site sediment and surface water was considered based on data developed by the individual facility's TRRP projects. Since submission of the PSCR in 2006 (Anchor 2006a), each facility has submitted groundwater-specific evaluation reports (Shell 2009; Lubrizol 2011; Oxy 2007). These reports provide data and evaluations that indicate groundwater from each facility has very little measurable interaction with Site sediments and surface water and facility COCs are not discharging to the Site. These conclusions were approved by TCEQ. The following provides a summary of these conclusions from these reports.

4.6.4.1 Shell Deer Park Facility

4.6.4.1.1 Sediment

In the groundwater evaluation report for the Shell Deer Park Facility and the Site (Shell 2009), a WOE evaluation is presented that describes multiple lines of evidence indicating, collectively, that:

> "…the Steering Committee [TCEQ stakeholders and Shell] determined that the results of these analyses support the conclusion that COCs in Site groundwater do not appear to cause or contribute to sediment toxicity in Patrick Bayou." (Shell 2009).

The WOE evaluation included:

- Chemical Correspondence Analysis (CCA) – to determine if "…there is a discernible relationship between the patterns of chemical occurrence and distribution in [groundwater and sediment]."
- Chemical Mass Loading (CML) – to determine "…if the mass loading contained within groundwater underlying the Site is sufficient to account for the chemical concentrations observed in Patrick Bayou sediment."
- Spatial Analysis of Toxicity (SAT) – "…to determine whether Patrick Bayou sediment toxicity test responses are related to chemical concentrations observed in groundwater underlying the Site."

The CCA analyzed chemical patterns for relevant chemical groups by a combination of visual data inspection (i.e., a qualitative spatial analysis of concentrations in groundwater and sediment) and multivariate statistical analyses. The exploratory pattern analysis used principal component analysis to examine potential spatial or concentration groupings among groundwater and sediment data. The statistical analyses included the Chi-square goodness-of-fit test and the Wilcoxon rank sum test.

To conduct the CML, hypothetical mass contributions (i.e., loading) for various chemicals were estimated using estimated groundwater flux into the Site and chemical concentration data for groundwater underlying the Site. Specifically, predicted sediment concentrations were calculated using equilibrium partitioning and mass flux estimates. These predictions assumed that all chemical mass from groundwater underlying the Site was loaded to the top ten centimeters of sediment (i.e., the assumed biotic zone).

The SAT study consisted of four separate analyses, considering the average behavior and variability of sediment toxicity and groundwater chemistry data, spatial correlation in these data and the potential for correlation in outliers.

Collectively, the CCA, CML, and SAT analyses concluded that groundwater below the Shell property "…does not cause Patrick Bayou sediment toxicity…"

4.6.4.1.2 Surface Water

As described in Shell (2009), groundwater recovery systems and a low permeability slurry cut off wall are in place along the Site to prevent impacted groundwater discharge to the Site. Specifically, groundwater flow in two areas along the Site is controlled by a network of 33 recovery wells. To verify the hydraulic performance of these and other recovery efforts at the facility, Shell monitors a network of 151 wells (semiannually for wells in the uppermost WBZ and annually for wells in the lower two WBZs). Further, a 340-foot-long by 40-foot-deep slurry has been constructed along the Site to further control groundwater flow and enhance hydraulic capture of the recovery systems. As stated previously, these remedial actions are being conducted under Compliance Plan #CP-50099-001 and overseen by TCEQ. Given this, it is reasonable to conclude that potential impacts to Site surface water by affected groundwater at the Shell property are and will continue to be controlled.

4.6.4.2 The Lubrizol Corporation

4.6.4.2.1 Surface Water

Lubrizol completed an analysis of the potential groundwater impacts on Site surface water by conducting a numerical modeling study of groundwater and contaminant flux, as well as providing supporting lines of evidence to further support the hypothesis (*Evaluation of the Geologic and Groundwater Conditions at The Lubrizol Corporation* [Lubrizol 2011]). These analyses concluded that:

> "…COCs in groundwater from the Lubrizol Facility have no significant impact on the Patrick Bayou media." (Lubrizol 2011).

The numerical modeling study was conducted using the USGS MODFLOW v. 2009.1 numerical model to determine groundwater flux to the Site. The output of the MODFLOW analysis was used in a second numerical model, MT3DMS, to estimate fate, transport, and loading of COIs to the Site.

The results of the modeling indicated that the groundwater flux under active recovery network conditions from the Lubrizol facility to the Site represented approximately 0.01 percent of the average daily flow in the Site. Conservative estimates of loadings for chemicals of interest (PCBs and mercury) based on this groundwater flux did not exceed applicable ecological criteria for surface water.

4.6.4.2.2 Sediment

Based on the estimated loading rate for PCBs and mercury determined by the numerical modeling, and incongruence between many Site COCs and the Lubrizol COCs, the report concluded that:

> "…the groundwater contribution from the Lubrizol Facility to Patrick Bayou could only be considered insignificant and cannot account for the observed chemical mass in the bayou sediments." (Lubrizol 2011).

Regarding COC similarity, the most elevated Lubrizol COCs are alcohols, which are not Site COCs. Conversely, many Site COCs such as PAHs, lead, and BEHP are not Lubrizol COCs. Finally, NAPL is not present in any well at the Lubrizol facility.

4.6.4.3 OxyVinyls Deer Park Facility

4.6.4.3.1 Surface Water

In the Weston 2007 memorandum regarding the Patrick Bayou Groundwater Evaluation, a review of the performance of multiple groundwater remediation measures at the OxyVinyls facility was used to demonstrate that impacted groundwater from the facility has either been remediated to levels below applicable standards, or controlled sufficiently such that impacts to the Site are prevented. Three general areas of the OxyVinyls facility were evaluated with regard to system performance: Southwest Shoreline, West Shoreline Slurry/Cut-off Wall and North Shoreline, yielding the following summary conclusions, respectively:

> "…the flux of groundwater from the first WBZ to Patrick Bayou in this area is considered negligible." and "The flux of groundwater from the second WBZ upward to the first WBZ and to Patrick Bayou is considered negligible."
>
> "Due to the cutoff of potential upgradient groundwater recharge, the flux of groundwater from the first and second WBZs to Patrick Bayou in this area is considered negligible."
>
> "Historical detection of the VCP program chemicals of concern have been below action levels or non-detect."

The remediation systems at the facility, as described previously, consist of 31 recovery wells (both vertical and horizontal), a network of compliance monitoring wells, sheetpile, a low permeability slurry cut-off wall, and phytoremediation measures.

4.6.4.3.2 Sediment

Although not specifically evaluated in the 2007 memorandum, ongoing potential impacts, if any, to sediment in the Site from impacted groundwater from the OxyVinyls property would be considered negligible. Active remediation activities, including the low permeability slurry cut-off wall, have been in place for almost two decades and have continually demonstrated required groundwater (source) control.

4.6.5 Soil and Vadose Zone

By definition, soil and vadose zone contamination does not exist within the Site, due to its submerged nature. As discussed previously, facilities adjacent to the Site have conducted detailed TRRP/VCP investigations and performed remedial actions, overseen by TCEQ, related to contamination in both unsaturated and saturated media. These activities have resulted in control of impacted groundwater and, by extension, addressed residual contamination that may have been present in unsaturated media such as soils and the vadose zone.

5 SOURCE CHARACTERIZATION

The Site and the surrounding area have been used for industrial and commercial operations for nearly a century. Upstream areas have become heavily urbanized as the industrial and commercial nature of the area expanded. During this time, chemicals associated with those practices were released from various sources through migration pathways to the Site sediments, which may pose risk to receptors. Activities and processes that may lead, or may have led, to either point or nonpoint releases to the Site include petroleum refining, storage, and distribution; chemical manufacturing and formulation; urban development and use; agricultural applications; industrial shipping and use of the HSC; dredging of the HSC; industrial operations along the HSC; electrical substation operation and maintenance; and sewage treatment.

The primary focus of this section is the discussion, by pathway, of the historical and current sources that may have contributed to contamination within the Site. Although many specific sources of contamination are discussed, neither this section nor the RI Report in general is intended as an exhaustive list of current or historical sources of contamination. However, sufficient information about likely significant historical and current sources is available to inform the preparation of the FS.

5.1 Current and Historical Activities

Sources can be either historical or current in origin. Historical sources may have released chemicals to the Site in the past, but no longer have an upland source to control. Current sources are releases of chemicals from historical or current activities that are migrating to the Site through a migration pathway that needs to be controlled.

Historical releases are considered to have contributed to the majority of the observed chemical distribution in sediments within the Site. All the pathways described below have a historical component and many can be attributed entirely to historical operations or releases.

5.2 Direct Discharge

Based on what is known about the historical operations along the HSC and its tributaries and tidal streams, the historical direct discharge of waste materials to the HSC is perhaps the primary source of the observed sediment contamination in this area. In the early 1900s, rivers in the U.S. were generally used as open sewers, which was also true for the HSC (GBEP 2011). The region's untreated sewage, as well as process water from a variety of industries, primarily petroleum related, was discharged directly into the HSC and its tributaries. Stormwater runoff carried pollutants from nonpoint sources such as agricultural activities, industrial activities, impervious surfaces (e.g., roads), and uncontrolled releases (e.g., spills). Starting in the 1970s, these activities were gradually controlled through regulatory actions such as the Clean Water Act. Generally, by 1980, most of the direct point discharges (i.e., outfalls) were regulated under some authority and significant improvements in non-point discharge had occurred (GBEP 2011). The Site, being a tidal stream of the HSC located in a heavily industrialized and urbanized watershed, would follow a similar historical course and would have been subject to similar types of historical direct discharges. As described previously, industrial activities in the watershed began as early as the 1920s along with increasing urbanization of the watershed. Although precise information on historical direct discharge to the Site is not available, historical direct discharge, similar to discharges documented for the HSC, is considered the primary source of contamination within the Site. This model is also supported by the higher levels of COCs observed in deeper buried sediments at the Site.

Permitted outfalls and storm drains within the Site and upstream drainages are shown in Figure 5-1 and summarized in Table 5-1. Information and data on outfalls and storm drains were obtained from the City of Deer Park WWTP, Praxair, Glenn Springs Holdings, Lubrizol, and Shell.

There are four outfalls that currently discharge just upstream of the Site: City of Deer Park WWTP outfall, Lubrizol outfall 001, and two stormwater only outfalls (Lubrizol outfalls 002 and 006). Three other outfalls currently discharge directly into the East Fork Tributary: Praxair outfall 001, Rohm and Haas outfall 003 (stormwater), and Lubrizol outfall 007 (stormwater). Within the gunite-lined channel, seven outfalls currently discharge stormwater, domestic wastewater, and/or utility wastewater. Downstream of the gunite-lined channel, six outfalls (four Shell and two Oxy) currently discharge stormwater, non-process wastewater, fire water, and/or non-contact cooling water withdrawn from the HSC. One outfall, Oxy 001, was closed in 2010.

Currently, there are no known active discharges that add contaminants to the Site above NPDES discharge limits or above typical urban background loading. Thus, current direct discharge to the Site from permitted outfalls is not considered a significant source of contaminants to the Site.

5.3 Groundwater Discharge

Contaminated groundwater may have entered the Site historically via discharge through sediments or bank seeps. While deeper groundwater bearing zones (i.e., below the Beaumont Formation) are not hydraulically connected to the Site, shallow groundwater bearing zones have some connection to the Site. Releases of chemicals to upland soils may have resulted in migration of these chemicals to groundwater, which subsequently migrated to the Site. Evaluation of historical groundwater pathways based on the available information is difficult, but groundwater may have been a source of chemicals to the Site historically. As discussed in Section 4.6.4, groundwater from each facility currently has very little measurable interaction with and does not contribute to COPCs observed in Site sediments and surface water.

5.4 Spills

There is no historical record of spills prior to 1958. Historical spills are potential sources of chemicals at the Site. A review of spill reports maintained by the Texas Parks and Wildlife Department from 1958 to 2005 (Denton 2006) revealed no documented spills at the Site during that time. Numerous spills have occurred in Segment 1006 of the HSC adjacent to the Site. Spills in the HSC could potentially travel via surface water into the Site.

5.5 Bank Erosion

Soils or fill containing chemicals may erode from unprotected banks of the Site and enter surface water or sediments. Much of shoreline has been modified by placement of fill over time. The sources and quality of these materials is unknown. If these materials were contaminated, they may have been a historical source of contamination to the Site as storm events eroded bank soils. Currently, much of the Site banks are covered with bank stabilization materials, which inhibit erosion. Unstabilized areas generally have natural cover as well to inhibit erosion; there are few if any significant areas of bare soil adjacent to the Site. Thus, there no known current sources of contaminants loading associated with bank erosion for the Site.

5.6 Atmospheric Deposition

Nearly all surface water bodies are exposed to potential deposition of chemicals in the atmosphere. Chemicals deposited to surface waters of the Site may come from local and regional point and non-point sources. Chemicals deposited to surface water may become dissolved in surface water, adsorbed to particulates in surface water, or may adsorb to sediments. PAHs, PCBs, mercury, and PCDDs/PCDFs are common atmospheric pollutants in urbanized environments and are expected to represent both current and ongoing sources of contamination to the Site.

5.7 Houston Ship Channel Interaction

The HSC is known to be impacted by several contaminants, including PAHs, PCBs, PCDDs/PCDFs, and mercury. The Site is tidally influenced and the tidal fluctuation produces an exchange of surface water between Patrick Bayou and HSC within the Site. Chemicals released, historically and currently, into the HSC may migrate into the Site as a result.

5.8 Upstream Sources

Potential upstream sources generally consist of point source discharges (outfalls), non-point urban runoff, and spills or intentional releases. Several permitted outfalls exist upstream of the Site (Section 5.2). The number and significance of historical outfalls is unknown. The upstream drainage also acts as the primary stormwater conveyance system for the City of Deer Park and chemicals in soils and impervious areas would quickly runoff into these typically concrete lined drainages and reach the Site. A report by NewFields (2010) identified several potential upstream sources within the Patrick Bayou watershed that could be contributing chemical loading to the Site. Sources included the City of Deer Park WWTP, automotive maintenance facilities, waste handlers, dry cleaners, and light industrial businesses. Based on these facilities and watershed land uses, metals, PAHs, pesticides, and nutrients were identified by NewFields as chemicals with potential loading to the Site. Measureable levels of PAHs and PCBs have been observed entering the Site from upstream areas (see Section 4.2.1.1) suggesting there is input of contaminants from upstream areas. The degree to which upstream areas have historically acted as source to the Site cannot be fully assessed. Upstream contributions of PCBs to the Site are being evaluated as part of the chemical fate and transport model being developed for the FS Report. This model should provide insight on the significance of upstream areas as a current source of selected contaminants to the Site.

6 CHEMICAL FATE AND TRANSPORT

As discussed in Section 4 the primary IC class at the Site is PCBs. Total PAHs, BEHP, and lead are also associated with some risk to benthic receptors and are secondary ICs.

The fate and transport of PCBs and the secondary ICs is a function of their chemical properties and the physical conditions of the Site. This section provides a discussion of the chemical properties of the ICs, fate and transport processes, and the modeling framework that will be used to evaluate the fate and transport of ICs at the Site as part of the FS.

6.1 Chemical Characteristics of Indicator Chemicals

The degree to which the ICs move from sediment to water and become bioavailable is affected by the solubility of the constituent in water, the tendency of the constituent to adsorb to sediment particles, and the rate at which the constituent degrades in the environment. The parameters used to characterize these properties are the water solubility, partition coefficient, and biodegradation rate of each chemical. The primary ICs for the Site (PCBs) and most of the secondary ICs do not volatilize to a significant degree, so properties related to volatilization (primarily Henry's Law constant) are not discussed further. Low molecular weight PAHs (e.g., naphthalene) and BEHP are more volatile in some environmental settings, and volatilization will be considered for these ICs if they are present to a significant degree. Table 6-1 presents a summary of the chemical properties for the ICs.

ICs with lower water solubility and higher partition coefficients have less potential to enter the aqueous phase and become mobile. ICs that are strongly adsorbed to the sediment may be transported with sediment if the sediment is resuspended by high surface water velocities and can also be exchanged between sediment porewater and surface water. The following subsections describe the relevant chemical properties of the ICs.

6.1.1 Polychlorinated Biphenyls

In general, PCBs are less soluble in water and adsorb more strongly to sediment than the other ICs. Although these properties make PCBs less bioavailable than the other ICs, PCBs tend to bioaccumulate (PCBs that enter an organism tend to be stored rather than broken down or excreted), which can increase the potential effect of PCBs on the food chain.

Chemical properties are more difficult to define for groups of chemicals, such as PCBs, than for individual constituents. In general, less chlorinated PCBs are more water soluble and adsorb less strongly to sediment than the more chlorinated PCBs. This tendency is illustrated by the relatively low solubility and high partition coefficient for the tetra-substituted homologs as compared to the tri-substituted homologs (Table 6-1). The heaviest PCB, PCB-209 (decachlorobiphenyl) is even less water soluble and partitions more strongly to sediment than the tetra-substituted PCBs. The lighter PCBs also tend to be more biodegradable under aerobic conditions. Anaerobic biodegradation has also been reported in some cases, although anaerobic degradation tends to focus on the heavier PCBs. Reductive dechlorination by aerobic or anaerobic organisms tends to focus on the meta- and para-chlorines. Ortho-substituted PCBs are less likely to be biodegraded but these PCBs are also less toxic than the coplanar PCBs (Field et al. 2007). The very large majority of sediments at the Site are anaerobic, and degradation of PCBs is typically quite slow under those conditions to the point that degradation of PCBs in sediments is generally not considered an important process on the timescales of interest for the RI/FS.

6.1.2 Total Polycyclic Aromatic Hydrocarbons

As with the group of PCBs, PAHs, as a group, are complex to evaluate and the data presented in Table 6-1 indicate a wide range of chemical properties. Certain PAHs (e.g., acenaphthene and naphthalene) are more likely to be present in the aqueous phase than other PAHs because they have higher solubility in water and lower partition coefficients. However, acenaphthene and naphthalene, in particular, have relatively short half lives in aerobic conditions, which may prevail in shallow surface water. Other PAHs (e.g., benzo(k)fluoranthene and indeno(1,2,3-cd)pyrene) have significantly less solubility in water and higher partitioning coefficients. These ICs are not likely to be present in the aqueous phase and have relatively long half-lives under anaerobic conditions that are present in sediment at the Site.

Generally, PAHs are more soluble than heavier PCBs (e.g., PCB-209) and less soluble than BEHP. Despite having a greater solubility than heavier PCBs, PAHs are less bioaccumulative because they are metabolized by organisms. Certain PAHs (e.g., anthracene, fluoranthene, and pyrene) demonstrate similar solubility and bioavailability as lighter PCBs (e.g., tri- and tetra-substituted PCBs), while naphthalene and acenaphthene are approximately an order of magnitude more soluble than tri-substituted PCBs.

6.1.3 Bis(2-ethylhexyl) Phthalate

Data presented in Table 6-1 indicate the solubility and partitioning coefficient of BEHP is similar to tri-substituted PCBs. Biodegradation of BEHP has been reported with a half-life range of 41 to 389 days in anaerobic conditions, which are likely in subsurface sediment at the Site (USEPA 1996). Aqueous BEHP is also relatively biodegradable within the aerobic conditions likely present in the shallow surface water of the Site. The aerobic half-life of BEHP is between 5 and 23 days (USEPA 1996; Table 6-1).

6.1.4 Lead

The solubility of metals, including lead, is highly dependent on water chemistry, which affects the speciation of the metal. Lead is reported as insoluble in water at neutral and higher pH (USEPA 2007). Lead can react with a variety of negative radicals (such as sulfide, sulfate, and carbonate) to form insoluble salts.

Analytical tests performed on samples from the Site provide multiple lines of evidence that the lead found at the Site may not be bioavailable:

- The AVS and SEM analyses test whether the amount of sulfide radicals present in the environment is sufficient to sequester the available divalent metals, such as mercury and lead. When the molarity of AVS exceeds the molarity of SEM, the SEM are present in the form of insoluble sulfide salts that are not bioavailable (USEPA 2000). The AVS/SEM analyses summarized by Anchor QEA (2010) demonstrate that sufficient sulfide is present at the Site to sequester all of the available lead as insoluble sulfide minerals.
- Lead was not detected in porewater (Anchor 2008a).
- Tissue samples were not analyzed for lead as it was not identified as a COPC for fish or wildlife. Lead was excluded as a COPC based on simple bioaccumulation modeling of bulk sediment data using biota-sediment accumulation factors, which did not result in predicted tissue concentrations above a risk-based screening level (Anchor 2008a).

6.2 Fate and Transport Processes

The general processes affecting fate and transport of sorptive chemicals within an aquatic system are depicted on Figure 6-1. External loads of chemicals can enter the area of interest as point sources (e.g., tributaries or outfalls) or distributed sources (e.g., atmospheric deposition or surface runoff). Hydrodynamic processes such as freshwater flow and tidal circulation cause chemicals to be transported within the water column in the direction of the currents. The transport of ICs to the Site from external sources is discussed in Section 4. Other fate processes that occur in the water column include partitioning between dissolved and particulate (i.e., adsorbed to suspended sediment) phases, as well as to dissolved organic carbon in some cases, and degradation reactions (for some chemicals and under certain conditions). Chemicals in the water column can be lost to the atmosphere via volatilization, depending on their characteristics. Chemicals are also exchanged with the underlying sediment bed via the processes of deposition and resuspension of sediments and associated particulate-phase contaminants, and by porewater exchange flux. A number of fate and transport processes also occur within the sediment bed, including mixing (i.e., bioturbation) within the surficial sediments, vertical transport/exchange within the porewater, as well as partitioning and biodegradation (when applicable). In a net depositional environment, there is a net transfer of contaminants from the surficial layers to the deeper layers of the bed (i.e., burial).

The processes described above can be grouped into three general categories: hydrodynamics, sediment transport, and chemical fate. The subsections that follow provide a more detailed discussion of these processes as they apply to PCBs within the Site. Similar processes would occur for other hydrophobic COCs at the Site with the exception that some COCs, including PAHs and BEHP, would be more likely to degrade, especially under aerobic conditions.

6.2.1 Hydrodynamics and Sediment Transport Processes

To address abiotic processes governing fate and transport of ICs within the Site, a linked numerical model was developed to describe the hydrodynamic environment at the Site and sediment transport characteristics within the Site. A watershed model was used to assess flows into and out of the Site, and the flow regime was used in the hydrodynamic model and STM. These models are directly relevant to all ICs. A detailed description of the technical approach used in the STM for the Site is described in the *Sediment Transport Modeling Report* (Anchor QEA 2012b). That report also provides a detailed account of results of the site-specific modeling to date. A summary of the hydrodynamic and *Sediment Transport Modeling Report* is also presented in Section 5 of this document.

A final model that provides a tool for evaluating the chemical fate and transport of the IC class of PCBs is under development for the Site and will be reported on and used in the Site FS. A summary of the chemical fate modeling effort is provided in Section 6.3.

6.2.2 Chemical Fate Processes

The key chemical fate processes affecting PCBs and similar sorptive compounds within the aquatic environment of the Site include:

- Sediment-water interactions – Because of the hydrophobic nature of PCBs, they preferentially bind to particulate matter. As discussed above, the extent of hydrophobicity varies by congener, with the lighter, less chlorinated congeners exhibiting less hydrophobicity than the heaver, more chlorinated congeners. The sediment bed, therefore, serves as a net sink, adsorbing PCBs. To the extent that PCBs may have accumulated within the bed over time (e.g., if there were historical releases and subsequent transport), they can act as a source to the water column, and chemicals being transported in the water column can likewise deposit on the bed. The flux of sediment particles (and particle-bound PCBs) between the bed and water column are driven by sediment deposition and erosion processes, especially during episodic events such as floods and hurricanes. Deposition also provides a mechanism for natural recovery if concentrations of PCBs on particles in the water column are lower than those at the bed surface. Thus, within-bed dynamics such as transfers between surface and deeper layers of the bed are also important.
- Partitioning and dissolved phase flux – The distribution of PCBs between the particulate and dissolved phases within the water column and bed sediments are determined by their partitioning behavior (as quantified by the partitioning coefficient). Because they are hydrophobic (as indicated by relatively high K_{OC}; Mackay et al. 1992), PCBs will primarily be present in particulate form, which means that their fate is largely determined by sediment transport processes. However, in

areas where PCBs have accumulated within the surface layer of the sediment bed, partitioning will result in porewater concentrations that can be much greater than those in the overlying water column. Such a concentration gradient, through the process of surface exchange flux (due to diffusion, bioturbation, and tidal pumping), results in a transfer of dissolved-phase mass to the water column that can affect concentrations in the Site under low flow conditions.

- Transport in the water column – PCBs that are present in the water column, in both dissolved and particulate phases, are transported with the currents, which are affected by freshwater flow in addition to more complex circulation patterns associated with the tides. Transport in the water column differs depending on the flow regime, since the relative importance of freshwater flow and tidal action, as well as the fate and transport processes that are active, differ by flow conditions. For example, under higher flow conditions, transport associated with sediment deposition and erosion is much greater.
- Inputs from external sources – In addition to fluxes from the sediment bed, which are considered an internal source, PCBs also enter the aquatic environment within the Site via external sources. As documented in Section 4.6, transport of ICs via groundwater to the Site may have been significant historically but corrective actions have blocked this pathway for the Site. PCBs were detected in surface water samples collected upstream of the Site, as well as in the East Fork, albeit at relatively low concentrations. Furthermore, PCBs were detected in the HSC upstream of the Site and in dry and wet atmospheric deposition samples that were collected adjacent to the Site as part of the TMDL study (Rifai and Palacheck, 2006, 2007, 2008, 2009, 2010). These processes therefore represent external sources to the aquatic environment of the Site.
- Other loss processes such as volatilization and degradation reactions are generally not important for PCBs (e.g., USEPA 1994). Nevertheless, these processes are being evaluated as part of the modeling effort.

6.3 Summary of Fate and Transport Modeling Study

The mathematical modeling framework being applied in this study consists of hydrodynamic, sediment transport, and chemical fate and transport models that are linked together (Figure 6-2). The hydrodynamic model accounts for the effects of the following factors on water movement in the Site:

- Freshwater inflow from upstream areas, including runoff and discharge from the City of Deer Park
- Freshwater inflow from the East Fork, as well as direct surface runoff and stormwater outfalls within the Site area
- Tidal movement and associated exchange with the HSC
- Density-driven circulation (i.e., salt wedge development) caused by mixing of saline to brackish water in the HSC with freshwater inflows upstream in the Site

The hydrodynamic model is used to simulate temporal and spatial changes in water depth, current velocity, and bed shear stress. This information is transferred from the hydrodynamic model to the STM, where it is used to simulate the erosion, deposition, and transport of sediment in the Site. The STM is used to simulate temporal and spatial changes in suspended sediment concentrations in the water column and bed elevation changes (i.e., bed scour depth and NSR). The results from the hydrodynamic and STM are transferred to the chemical fate and transport model, which calculates spatial and temporal variations of PCB concentrations in the water column and sediment bed of the Site by simulating the various processes described in Section 6.2.2 above.

The hydrodynamic, sediment transport, and chemical fate and transport models are constrained by governing equations that are based on the conservation of mass and momentum. Mechanistic formulations and algorithms based on the state of the science are used in these models to simulate the processes governing the movement of water, sediments, and contaminants. The formulations and algorithms used to simulate sediment deposition and erosion and contaminant fate processes are based on empirical information and data from a wide range of laboratory and field studies. In addition, data collected from within the Site were used to determine the various parameters used in the models, which provides additional constraints on the models.

As noted above, a detailed description of the technical approach used in the Site modeling is described in the *Sediment Transport Modeling Report* (Anchor QEA 2012b). A final model that provides a tool for evaluating the chemical fate and transport of the IC class of PCBs is under development for the Site and will be reported on and utilized in the Site FS to evaluate baseline conditions and the effect of potential remedial alternatives on water quality issues associated with PCBs in sediments at the Site. Together, these models describe internal and external loading of PCBs to the aquatic and sediment environment, interactions between media within the aquatic system, and the physical movement of PCBs and other COCs. The models were built with site-specific data and can be used to evaluate outcomes of risk management strategies in the FS.

7 BASELINE RISK ASSESSMENT

Consistent with Task 4 of the SOW for the AOC, human health and ERAs for the Site were performed as part of the RI. The baseline human health and ecological risk assessments were submitted and approved by USEPA prior to the completion of the RI Report. Each report is summarized in the following the sections. Full results and analysis can be found in the BHHRA Report (Anchor QEA 2012c) and BERA Report (Anchor QEA 2013a).

7.1 Human Health Evaluation

This section summarizes the results of the human health risk assessment that were included in the previously submitted BHHRA Report (Anchor QEA 2012c) accepted by USEPA in April 2013. The human health risk assessment was performed consistent with the BHHRA Work Plan (Anchor QEA 2011d), following standard USEPA guidance for human health risk assessments including Risk Assessment Guidance for Superfund (RAGS)[30], and as directed by USEPA. In addition, state guidance (TNRCC 2001; TCEQ 2006) was considered where appropriate.

7.1.1 Conceptual Site Model

The BHHRA CSM was developed for the Site to illustrate known and suspected sources of chemical contamination, types of chemicals and affected media, known and potential routes of migration, and known or potential human receptors (Figure 7-1). Based on the CSM, the following key points are related to potentially exposed populations: 1) the entire shoreline of the Site is lined by three major industrial properties: Shell, Lubrizol, and Oxy; 2) for safety reasons, the industries located along the shoreline of the Site restrict public access 24-hours per day, 7-days per week, and require escorts while on-site; 3) Captain of the Port of Houston restricts vessel traffic in the HSC adjoining the Site; and 4) several above ground industrial pipelines and a bridge crossing near the HSC physically restrict access by boat. Thus, access by the public is restricted and fishing within the Site is not likely to occur now or in the foreseeable future.

[30] http://www.epa.gov/oswer/riskassessment/human_health_exposure.htm

The Texas Department of Health (TDH), under a cooperative agreement with the Agency for Toxic Substances and Disease Registry (ATSDR), reviewed available environmental information for the Site and evaluated the primary pathways through which people might possibly come into contact with contaminants from the Site. The TDH concluded that, based on available information, people are not coming in contact with Site contaminants; therefore, the Site does not pose a public health hazard. As a result, the on-site potentially exposed populations were restricted to on-site utility and construction workers in the CSM.

Off-site subpopulations of concern for the Site consist of groups who might be at increased risk for toxic effects from chemical exposures. Fishing and crabbing may occur within the HSC in spite of the current TDH fish and shellfish advisories along the HSC. The subpopulations of concern are fishermen and their families, who may catch and consume fish or shellfish (specifically blue crabs) that have been exposed to Site COPCs. Because access to the Site is not possible for purposes of recreational activities, including fishing and crabbing, the point of exposure (POE) was assumed to be in the vicinity of the San Jacinto Battleground State Historic site in the BHHRA. This area is the nearest downstream, off-site location from the Site where fishing and crabbing are likely to occur.

7.1.2 Exposure Assessment

The following exposure scenarios were addressed in the BHHRA:

1. On-site exposures for utility and construction workers that could be exposed to on-site sediment in the future due to construction activities that might include dredging; seawall or riprap repair; pipeline or bridge installation, removal, or repair; or other similar activities. These workers could be exposed to the COPCs in both surface and sub-surface sediment via the incidental ingestion of sediment and/or through dermal contact with sediment.
2. Recreational fishing is known to occur at the San Jacinto Battleground State Historic site, an off-site location in the HSC approximately 1.6 miles downstream of the Site. These fishermen (adults) and their families, including children, could be harvesting both fish and blue crabs for personal consumption from this location (i.e., a POE). Because it is not known whether, or to what degree, these fish and crabs have been

exposed to COPCs from the Site, several approaches were used to evaluate the significance of this pathway.

The significance of the exposure pathway from Site COPC to fish and shellfish caught at the San Jacinto Battleground State Historic site was evaluated using Site tissue data and the tissue data in the HSC collected by third parties (see Section 2). These data were evaluated in the BHHRA using spatial, congener pattern, and statistical discriminant analyses to evaluate the significance of the off-site exposure pathway described above.

The spatial analyses suggested that there is no observable incremental contribution from the Site to the average concentrations of PCBs or dioxins and furans as TEQs found in the HSC fish and shellfish at the POE, or otherwise.

A graphical congener pattern analyses demonstrated there is a dominance of lower chlorinated PCB congeners in Site blue crab and hardhead catfish, while higher chlorinated PCB congeners are more dominant in HSC blue crab and hardhead catfish. For PCBs, this analysis demonstrated that there are clear differences in the relative composition of PCB congeners in Site fish and shellfish compared to fish and shellfish in the HSC.

Congener pattern analyses for the dioxins and furans showed the proportion of octachlorodibenzofuran (OCDF) and octachlorodibenzo-p-dioxin (OCDD) relative to other congeners for blue crabs is much lower at the Site than in the HSC. Differences in congener ratios are also apparent for 1,2,3,7,8-pentachlorodibenzofuran (PeCDF), 1,2,3,6,7,8-hexachlorodibenzo-p-dioxin (HxCDD), and 1,2,3,4,6,7,8-heptachlorodibenzo-p-dioxin (HpCDD) in blue crab. Similarly, the proportion of OCDF and OCDD is much lower in hardhead catfish from the Site than the HSC. Overall, graphical analysis indicated that there are apparent differences in the relative composition of PCDD/PCDF congeners in Site fish and shellfish compared to fish and shellfish in the HSC.

Discriminant analysis was used to further evaluate differences and similarities in fish and shellfish samples collected in different locations along the HSC and the Site based on a specific set of parameters. When blue crab tissue data were evaluated as ratios of PCB congeners to total PCBs, no similarities between Site and HSC blue crabs were found.

Similar to the blue crab analysis, when hardhead catfish tissue data were evaluated as ratios of PCB congeners to total PCBs, no similarities between Site and HSC fish were found for any locations. When blue crab tissue data were evaluated as ratios of dioxin/furan congeners to total dioxin/furans, no similarities between Site and HSC blue crabs were found. Similarly, when hardhead catfish tissue data were evaluated as ratios of dioxin/furan congeners to total dioxin/furans, no similarities between Site and HSC fish were found.

7.1.3 Toxicity Assessment and Risk Characterization

Because the spatial analyses did not indicate an incremental contribution from the Site to the HSC at the POE and the discriminant analysis did not predict any similarity between Site and POE fish/shellfish for dioxin/furan congeners, the exposure pathway from the Site to the POE was not considered a significant source of exposure. Therefore, no risk characterization is warranted for fishermen and was not performed in the BHHRA.

The remaining exposure pathway evaluated for risk was for the on-site utility/construction workers that could be exposed to on-site sediment in the future due to construction activities. Estimated non-cancer hazards for utility/construction workers from the future on-site exposure to non-carcinogenic COPCs were based on the incidental ingestion of sediment and the dermal absorption of sediment-associated COPCs. The results for non-cancer risks analyses show that none of the COPCs yielded hazard quotients (HQs) greater than 1.0. Furthermore, the hazard index (HI) under reasonable maximum exposure (RME) assumptions (upper-bound) for total dioxin/furan TEQ and total PCB TEQ was 0.07.

If either or both the HQ and HI for a chemical are equal to or less than one, it is believed that no appreciable non-cancer health effects will occur from exposure to Site COPCs. Therefore, the potential for non-cancer hazards for on-site utility/construction workers in the future were identified as highly unlikely from exposure to Site COPCs based on RME assumptions in the BHHRA.

Estimated cancer risks for future on-site utility/construction workers from exposure to carcinogenic sediment-associated COPCs were also based on incidental ingestion and dermal absorption. The risk analyses demonstrated that none of the COPCs resulted in an excess cancer risk of greater than 1 x 10^{-6}. Excess cancer risks that range between 1 x 10^{-6} and 1 x 10^{-4} are within the discretionary risk range identified by USEPA and are generally considered to be acceptable by USEPA. Therefore, potential excess cancer risks for future on-site utility and construction workers were identified as highly unlikely from exposure to Site COPCs based on RME assumptions in the BHHRA.

7.1.4 Conclusions and Risk Management Recommendations

Based on the analyses performed in this BHHRA for the Site, the following conclusions can be made with respect to potential risks for future on-site utility/construction workers and off-site fishermen:

1. No unacceptable excess lifetime cancer risk or non-cancer hazards exist for on-site workers that may come into contact with or incidentally ingest Site sediments as a result of maintenance or construction activities as the Site. No COCs were identified for this receptor; thus, risk management recommendations are not warranted.
2. Spatial and statistical analysis of fish and shellfish tissue data did not indicate an incremental contribution of COPCs (PCBs and PCDDs/PCDFs) from the Site to the fish and shellfish at the POE in the HSC that may be caught and consumed by fishermen and their families. Thus, this exposure pathway, while potentially complete, does not contribute significantly to incremental cancer risks or non-cancer hazards for these receptors. Thus, risks for this receptor were not quantitatively evaluated for this pathway or receptor and no risk management recommendations were identified.

7.2 Ecological Risk

This section summarizes the results of the ERA performed for the Site that were included in the previously submitted BERA Report (Anchor QEA 2013a), which was accepted by USEPA in April 2013. The BERA followed the ERA approach presented in the BERA Work Plan (Anchor QEA 2011a) and is consistent with USEPA Guidance for Conducting ERAs (USEPA 1997, 1998), and as directed by USEPA. In addition, state guidance (TNRCC 2001; TCEQ 2006) was considered where appropriate.

7.2.1 Problem Formulation

The BERA CSM illustrates known and suspected sources of chemical contamination, types of chemicals and affected media, known and potential routes of migration, and known or potential ecological receptors (Figure 7-2). Complete and potentially significant exposure pathways are identified for the following ecological receptors:

- Benthic invertebrate community
- Fish community
- Sediment-probing birds and omnivorous/herbivorous birds – spotted sandpiper
- Carnivorous wading birds – composite avian receptor[31]
- Piscivorous birds – belted kingfisher
- Omnivorous/herbivorous mammals – raccoon

The exposure pathways for these receptors include a combination of direct contact with sediment, sediment ingestion, biota ingestion, and contact with porewater and surface water.

The assessment endpoints for the selected receptors are based on protection and maintenance of the communities or populations they represent. Although the goal of the assessment endpoints is based on protection of communities and/or populations, the measurement endpoints for most ecological receptors evaluated in the BERA concern the survival, growth, and reproduction of the organisms in each receptor group[32]. This practice, which is common in Superfund ERA, requires the extrapolation of individual level effects to assess potential risks to the community or population being considered. As such, thresholds for effects in the BERA were set at a level that may cause limited adverse effects on individuals but, if not exceeded, are not expected to result in adverse effects to the community or population overall.

Estimates of risk for all receptors were performed using deterministic approaches. Single estimates of exposure, such as estimated dietary intake or empirical estimates of concentration of a COPC in sediment were compared to levels that may result in adverse

[31] A composite avian receptor based on several different species was chosen to represent the range of life histories, physical descriptions (e.g., body weight), and feeding strategies of species within this guild.
[32] The exception to this approach is the evaluation of benthic community composition measurement endpoint.

effects to ecological receptors. The exposure assessment quantifies the magnitude and spatial and temporal patterns of exposure to COPCs for ecological receptors identified during problem formulation. Consistent with the BERA Work Plan, the lowest observed adverse effects levels, or their equivalent, were used to define effects levels for risk estimates.

A HQ representing the ratio of estimated exposure to the adverse effects level was calculated for each receptor-COPC pair. Receptor-COPC exposure scenarios that result in HQs less than 1.0 are not expected to result in any adverse effects to either the individual receptor or the overall community or population of receptors represented by the receptor evaluated in the risk assessment. In addition to evaluating quantitative descriptions of ecological risks and threshold concentrations for adverse ecological effects, the risk characterization also presented information on the significance of the identified risks to support risk management decisions.

Several sources of uncertainty are associated with all Superfund risk estimates (USEPA 1997). Uncertainty in the BERA was primarily addressed through sensitivity analysis, whereby different point estimates of parameter uncertainty (e.g., treatment of non-detects) were used to bracket a range of risk estimates around the baseline scenario.

7.2.2 Wildlife Risk Assessment

Dietary exposure of wildlife to Site COPCs was the primary line of evidence (LOE) to assess risk to these receptor groups. Both prey tissue (e.g., fish and shellfish) and incidental sediment ingestion were considered in dietary dose estimates. Several potentially bioaccumulative COPCs, including PCBs, PCDDs/PCDFs, PAHs, lead, mercury, hexachlorobenzene, hexachlorobutadiene, 1,3-dichlorobenzene, and 1,4-dichlorobenzene, were identified in the BERA Work Plan and were evaluated for wildlife in the BERA. Only one COPC, PCBs expressed as 2,3,7,8-tetrachlorodibenzo-p-dioxin equivalents (i.e., PCB TEQs), was equal to or exceeded a HQ of 1.0 for two receptors: spotted sandpiper (HQ = 1.0) and belted kingfisher (HQ = 1.7). Uncertainty analysis indicated that HQs for these COPC-receptor pairs may be above or below the threshold of concern (HQ of 1.0) depending on the assumptions used to characterize risk, which demonstrates that within the ranges of exposure and effects variables evaluated, risks may or may not exceed a threshold of concern for these COPC-receptor pairs.

7.2.3 Fish Risk Assessment

Risks to fish were assessed using a body burden approach, comparing the concentration of COPCs in fish tissue to tissue levels that are expected to have adverse effects on fish. The BERA Work Plan identified PCBs, PCDDs/PCDFs, mercury, and selenium as bioaccumulative fish COPCs. Measured or estimated levels of these COPCs in whole body fish were compared to their corresponding effects levels. None of the COPCs exceed their respective effects levels (i.e., all HQs are less than 1.0). As a result, no adverse risk to fish populations from Site COPCs were identified.

7.2.4 Benthic and Aquatic Invertebrate Risk Assessment

Sediment chemistry, Site-specific toxicity tests, and data on the condition of the benthic community (e.g., abundance and diversity) are used to assess risk to benthic invertebrates from exposure to sediment COPCs.

Initially, benthic toxicity models were evaluated to determine if an empirical, Site-specific relationship between surficial sediment chemistry and observed toxicity in laboratory bioassays using Site sediment could be established. If such a model could be developed, toxicity in Site sediments could then be predicted across the Site using sediment chemistry alone. Several different quotient or toxic unit models that have been described in the open literature to assess this relationship were evaluated in the BERA Work Plan (Anchor QEA 2011a). The performance of each model was assessed by applying it to site-specific, co-located bulk sediment chemistry data and bioassay (i.e., toxicity) data for the marine amphipod. Of the models assessed, a mean quotient model using the Probable Effects Level (Long et al. 2006) was initially selected based on several performance criteria identified in the BERA Work Plan. This model, hereafter referred to as the mean Probable Effects Level-Quotient (PEL-Q), was refined using a series of optimization steps in the BERA Work Plan. This optimized model included four COPCs (total PCBs, total PAHs, lead, and BEHP) that demonstrated a statistically significant difference in concentration between toxic and non-toxic samples.

This toxicity model initially developed in the BERA Work Plan was refined and reevaluated during the BERA. During the development of the BERA, it became apparent that the toxicity model, as initially conceived, had several limitations that could not be resolved and that led to a significant amount of uncertainty in its utility and relevance as a primary LOE. Specifically, and in no particular order of priority, these limitations are:

- The lack of reference area toxicity tests to account for naturally occurring stressors and confounding factors (e.g., salinity acclimation and porewater ammonia) that may result in an unknown but potentially significant amount of conservative bias in the toxicity attributed to Site COPCs.
- The model, when applied to other test species, results in a high percentage of false positives, leading to a potentially significant amount of Site sediments to be falsely predicted as toxic.
- The analytical uncertainty in the PCB analysis in the toxicity sample dataset confounds the extrapolation of the sediment chemistry data to more recent samples.

Thus, the uncertainty in the model, which is primarily a function of the uncertainty in the data used to develop the model, did not lead to a sufficient level of confidence in the model to define the magnitude and extent of risks to the benthic community.

Therefore, a WOE approach was developed in the BERA to assess benthic risk. This WOE approach included the review and analysis of site-specific bulk sediment chemistry data, sediment bioassay data, and benthic community data as LOEs. The objective of the WOE approach was to use the apparent correspondence between the values or metrics assigned to the LOEs, and the overall strength of the correspondence, where it existed, to identify areas of the Site where measurable incremental risks to the benthic community due to exposure to site-related COPCs are deemed probable, indeterminate, or low. The way in which the degree and strength of correspondence among the three LOEs was factored into the consensus-based ranking of different areas of the Site is considered to be conservative (i.e., biased toward identifying areas as probable or indeterminate, rather than low). Twelve different locations within the Site with co-located synoptic bulk sediment chemistry, bioassay data, and benthic community were included in the analysis. Based on the WOE approach, two of these locations were identified as areas where incremental site-related risks to the benthic community are probable, five locations were identified as indeterminate areas, and five locations were identified as low (Table 7-1). PCBs were identified as a primary driver for probable risk locations and were designated as a COC for the benthic community in the BERA.

Finally, the BERA Work Plan identified PCBs as a surface water COPC for benthic and aquatic invertebrate communities. Surface water levels of PCBs did not exceed relevant effect levels for invertebrates. Thus, no risks to invertebrates from PCBs in surface water were identified.

7.2.5 Conclusions and Risk Management Recommendations

Based on the results of the evaluation, the following risk management recommendations were made in the BERA:

- PCB TEQ HQs for the sediment-probing and piscivorous bird receptor groups[33] are equal to 1.0 and 1.7 for spotted sandpiper and belted kingfisher, respectively. However, uncertainty analyses indicate that HQs for these COPC-receptor pairs may be above or below the threshold of concern (HQ = 1.0) depending on the assumptions used to characterize risk. Thus, within the ranges of exposure and effects variables evaluated, risks may or may not exceed a threshold of concern for individuals exposed to PCBs in Site media.
- Risks to fish populations at the Site are negligible and no risk management for this receptor group is necessary.
- Using a WOE approach, areas of probable benthic risk have been identified. Although a quantitative risk characterization for the benthic community could not be performed within the acceptable range of uncertainty in the BERA, it is apparent that probable risks to the benthic community are likely associated with bulk sediment PCBs. Although no specific risk management recommendations were provided in the BERA, it was recommended that risk management for this receptor group should be considered within the overall context of other risk management considerations (e.g., water quality standards) during the FS.
- Ecological[34] risk occurs along a continuum and there is not a quantifiable bright line

[33] Based on risks to the belted kingfisher.
[34] Risks to human health were not identified for the Site.

for those risks. Remedial alternatives should be evaluated in the FS that lower the overall Site and sub-area risk for areas that are characterized as indeterminate and probable risks. In concert with USEPA, quantitative tools should be developed to assess the ultimate risk reduction expected from a specific remedial alternative and that risk reduction score will be used as part of the effectiveness assessment for each alternative, along with USEPA's other FS criteria.

8 PRELIMINARY REMEDIAL ACTION OBJECTIVES

The PRAOs for the Site were developed based on previous work jointly conducted by the JDG, USEPA, TCEQ, and other stakeholders, in consideration of USEPA guidance, and were originally presented and discussed in the PSCR (Anchor 2006a) and expanded upon in the *Remedial Alternatives and Technology Screening Report* (Anchor QEA 2013b). The PRAOs broadly define the overall goals of the project and recognize the industrial and commercial nature of the Site and surrounding areas, consistent with USEPA guidance concerning the consideration of land use in the development of RAOs (USEPA 1995, 1998).

In the case of Patrick Bayou, the watershed has been extensively altered for commercial, industrial, and waste management purposes. A decision consequence analysis (DCA) process (fully described in Appendix F of the PSCR [Anchor 2006a]) included JDG, stakeholder, and agency representative participation as part of a Patrick Bayou DCA Working Group. This Group evaluated the current conditions of the Site, controllable and uncontrollable stresses to the Site, current and future uses of the Site, and attempted to identify the long-term goals for improving the functions of the Site (e.g., industrial and municipal discharge watercourse, ecological habitat). The findings of that Group were that the potential ecological functions and associated human uses would be reduced from natural conditions at the Site even if contamination were absent. In addition, anthropogenic sources of contamination, such as urban and industrial runoff, are likely to continue to be non-point sources of contamination to the Site that will not be addressed by on-site management actions.

The urban and industrial nature of the Site and the long-term commitment to these uses must be considered in selection of an overall management goal. Given the physical setting of the Site, the overall PRAO is to protect populations of sensitive ecological receptors that may feed at the Site and prevent measurable degradation of downstream resources from Site sediment relocation. Protection and restoration of resources within the Site itself will be assessed in the context of the land use activity within the Site watershed.

The PRAOs, as stated in the PSCR (Anchor 2006a), are as follows:

- Primary Objective
  - Prevent adverse effects on wildlife species that may feed at the Site and prevent measurable degradation of downstream ecosystems, as a result of the transport of contaminated sediment from the Site.
- Secondary Objectives
  - Achieve measurable improvements in total ecological system functions.
  - Maintain remedy flexibility in response to remedy monitoring data.
  - Minimize long-term human interaction needed to maintain the remedied system.

Subsequent to the PSCR (Anchor 2006a) and based on the conclusions of the BERA Report (Anchor QEA 2013a), protection of benthic invertebrates from sediment toxicity associated with PCBs and secondary COCs (PAHs, lead, and BEHP) was identified as an additional PRAO. This PRAO is considered a primary objective.

8.1 Application to the Remedial Investigation/Feasibility Study

The primary PRAOs focus on managing adverse effects on wildlife and benthic invertebrates due to sediment toxicity primarily associated with PCBs. The BERA Report (Anchor QEA 2013a) identified potential unacceptable ecological risks to piscivorous and shorebird populations. Baseline PCB TEQ HQs for these receptor groups are equal to 1.0 and 1.7 for spotted sandpiper and belted kingfisher, respectively. However, uncertainty analyses indicate that HQs for these COPC-receptor pairs may be above or below the threshold of concern (HQ = 1.0) depending on the assumptions used to characterize risk. Thus, within the ranges of exposure and effects variables evaluated, risks may not exceed a threshold of concern for receptors exposed to PCBs in Site media.

Using a WOE approach that included three LOEs (sediment chemistry, sediment toxicity tests, and benthic community data), PCBs were identified as a COC for the benthic community in the BERA Report (Anchor QEA 2013a). Areas of probable risk were identified based on a consensus of the three LOEs evaluated. However, the available data did not support a quantitative estimate of the magnitude of risk within these areas.

Incremental risk to benthos and wildlife is driven primarily by exposure to PCBs. Although the BERA contained no specific risk management recommendations, it recommended that risk management based on risks to ecological receptors should be considered within the overall context of other risk management considerations (e.g., water quality standards) and consistent with the PRAOs defined above.

The designated uses of the Site, as defined by TCEQ in Title 30, Part I, Chapter §307.10, Appendix A of the Texas Administrative Code, include industrial discharge and navigation; however, it is also recognized that the Site provides ecological habitat and benefit to a variety of receptors (e.g., benthos, fish, birds, and small mammals). The physical conditions of the Site, including natural variations in stream flow, bed configuration and substrate, hydraulic gradient, grain size, and the land uses (which are reflected in parameters such as salinity and dissolved oxygen) will prevent restoration of the Site to a uniform measure of ecological function. Because of these limitations, the ultimate focus of the RI/FS is to develop a strategy for producing beneficial changes by identifying and managing the controllable stressors on the Site ecosystem.

The secondary PRAOs focus on providing a positive rate of improvement in regard to system function and lowering of ecological risks through an efficient process. Efficiency is measured based on time, area, cost, and overall effort in both the investigation and remediation of the Site.

Due to the absence of potential adverse effects to human health from contaminants at the Site, PRAOs specific to protection of human health are unnecessary. As noted in the BHHRA (Anchor QEA 2012c), the entire shoreline of the Site is lined by three industrial properties: Shell, Lubrizol, and Oxy. For safety and security reasons, these industries located along the shoreline of the Site restrict public access 24-hours a day, 7-days a week and require that visitors are escorted while on-site. There are also several above-ground industrial pipelines crossing the Site near the confluence of the Site and the HSC that effectively restrict access by boat. Furthermore, the Captain of the Port of Houston-Galveston has established security zones for certain areas within the Houston and Galveston area that include the portion of the HSC where Patrick Bayou enters. The security zones exclude recreational and unauthorized vessels from these areas, which prevents or discourages access to the Site through the HSC. Therefore, the BHHRA (Anchor QEA 2012c) concluded that public access for fishing or recreation within the Site is not considered a route of exposure to Site COPCs, now or in the foreseeable future. The BHHRA also made the following additional conclusions:

- The likelihood of exposure to contaminants in groundwater or air is low to nonexistent and these exposure pathways are considered incomplete.
- Unacceptable adverse risks (carcinogenic and non-carcinogenic) to workers at the facilities that may be exposed to Site sediments or surface water are highly unlikely now or in the foreseeable future.
- Due to the inaccessibility of the Site to the public, exposure to contaminants through ingestion of contaminated seafood obtained from within the Site is highly unlikely and not a complete exposure pathway. To further assess potential exposure to contaminated biota, the BHHRA evaluated the potential for off-site fishermen to catch and consume fish that may have been exposed to Site contaminants. Using discriminant analysis, it was shown that the exposure pathway from the Site to the nearest off-site point of exposure (i.e., San Jacinto Monument) for recreational fishermen is insignificant, and no further risk analysis was necessary for this subpopulation.

The conclusions of the BHHRA are also reflected in an earlier document by the TDH (2003). The TDH, under a cooperative agreement with the ATSDR, reviewed available environmental information for the Site and evaluated the primary pathways through which people might possibly come into contact with Site-related chemicals. As summarized above, those potential exposure pathways included groundwater, sediment, surface water, seafood, and air. The TDH concluded that people are not coming in contact with Site-related chemicals; therefore, the Site does not pose a public health hazard.

8.1.1 Pathway Elimination

As summarized in the *Remedial Alternatives and Technology Screening Report* (Anchor QEA 2013b), there are no known controllable active sources of chemicals to the Site surface water or sediments for air, groundwater, surface water, soil, active outfalls, or spills. There is likely ongoing loading of COCs and other chemicals to the Site sediments and surface water from ongoing urban runoff drainage, the WWTP at the City of Deer Park, and air deposition. Based on this outcome for source control and the available RI/FS data for sediments and surface water, any potential remedial actions at the Site should be focused on controlling exposure pathways for ecological receptors through direct sediment contact, sediment and surface water interaction, and surface water. These pathways are most effectively addressed through sediment-based remedial actions, which would also address potential water quality concerns associated with PCBs.

8.2 Applicable or Relevant and Appropriate Requirements

The development and evaluation of remedial alternatives will include an assessment of the ability of the remedial alternatives to address ARARs of environmental laws and other standards or guidance to be considered (TBC). Table 8-1 provides a broad summary of potential ARARs and TBCs that will be considered in the FS. The list includes certain citations that are not applicable to the Site, so as to document the basis for eliminating these regulations, standards, or guidelines from consideration (e.g., due to the chemical characteristics of the COCs, no remedial action is expected to result in emissions that would trigger the need for an operational permit under the Clean Air Act). Many of the ARARs and TBCs in Table 8-1 will be relevant to only some remedial alternatives that may be developed, but all of the requirements that may be relevant to any of the remedial alternatives are identified in the list.

Once a remedial action is selected, a detailed review of ARARs specific to the selected remedial action will be conducted and included in the *Design Analysis Report* for the selected action.

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TABLES

Table 2-1
List of Historical and Third Party Data Included in the RI/FS Project Database

Report/Source Title	Year Published	Report/Source Description	Sampling Description	Sponsor(s)	Prepared By
Assessment of Sediment Toxicity and Quality in Patrick Bayou, Segment 1006, Harris County, Texas	2002	Report describing the results of a third party TMDL conducted in cooperation with the TCEQ and the Patrick Bayou Community using the sediment quality triad approach for evaluation of sediments in Patrick Bayou.	Sediment collected from 19 stations in Patrick Bayou for bulk sediment chemistry, solid-phase toxicity testing, and benthic community assessment. Samples were collected in April 2000 and September 2001.	Patrick Bayou TMDL Lead Organization	Parsons Engineering Science; Dr. Cynthia Howard, University of Houston-Clear Lake; Mr. James Horne, PBS&J
Assessment of Sediment Toxicity and Quality in Patrick Bayou, Segment 1006, Harris County, Texas	2004	Joint TMDL Lead Organization / TCEQ / EPA effort to conduct sampling to determine causes of sediment toxicity in the Segment 1006A portion of the Houston Ship Channel (HSC); parallel sediment sampling and testing conducted by Parsons, University of Houston-Clear Lake, PBS&J, and Severn Trent Laboratories	Sediment samples collected from six previously sampled locations for bulk sediment chemistry, solid-phase toxicity testing, and benthic community assessment. Samples were collected in August 2003	Patrick Bayou TMDL Lead Organization	Parsons Engineering Science; Dr. Cynthia Howard, University of Houston-Clear Lake; Mr. James Horne, PBS&J
TCEQ (no date)	--	TNRCC / TCEQ maintains an online searchable database containing sample records in electronic format.	Periodic surface water data collections; dissolved metals concentrations in surface water from July 1996 to August 2005.	TNRCC / TCEQ	TNRCC/ TCEQ
Characterization of Potential Health Risks Associated with Consumption of Fish or Blue Crabs from the HSC, the San Jacinto River (Tidal Portions), Tabbs Bay, and Upper Galveston Bay	2005	Report describing potential risk associated with fish and shellfish consumption from the HSC and the need to continue or expand fish consumption advisories for the HSC.	Analyzed the edible portion of thirty five fish and ten shellfish (blue crab) samples collected within the HSC, San Jacinto River, Tabbs Bay, and Upper Galveston Bay for metals, selected pesticides, and PCBs.	TDSHS[1]	TDSHS - SALG[2]
Health Consultation – HSC and Tabbs Bay	2001	Report describing potential risk associated with fish and shellfish consumption from the HSC and the need to continue or expand fish consumption advisories for the HSC.	Analyzed the edible portion of twenty four fish and eight shellfish (blue crab) samples collected within the HSC, San Jacinto River, Tabbs Bay, and Upper Galveston Bay for metals, selected pesticides, PCBs, SVOCs, VOCs.	TDH	TDH-SSD
TCEQ (no date)	--	TCEQ performs environmental monitoring within Patrick Bayou as part of routine and special study sampling for bulk sediment chemistry, solid-phase toxicity testing, and benthic community assessment.	Samples collected at five locations within Patrick Bayou in 2003[3] and three locations in 2006.	TCEQ	Dr. Linda Broach, TCEQ (personal communication)

[1] Formerly Texas Department of Health (TDH)
[2] Formerly Seafood Safety Division (SSD)
[3] Samples collected in 2003 were split samples collected in conjunction with Parsons et. al (2004).

Table 2-1
List of Historical and Third Party Data Included in the RI/FS Project Database

Report/Source Title	Year Published	Report/Source Description	Sampling Description	Sponsor(s)	Prepared By
Total Maximum Daily Loads for PCBs in the HSC	2006-2007	The overall purpose of the TCEQ project is to develop a total maximum daily load (TMDL) allocation for PCBs in the HSC System, including upper Galveston Bay.	In 2002-2004, PCB congeners were analyzed in fish including hardhead catfish and blue crab. Data are presented in quarterly reports between 2006-2007.	TCEQ	H. Rifai and R. Palachek
Total Maximum Daily Loads for Dioxins in the HSC	2006	The overall purpose of the TCEQ project is to develop a total maximum daily load (TMDL) allocation for dioxin/furans in the HSC System, including upper Galveston Bay.	In 2002-2004, dioxin/furan congeners were analyzed in fish including hardhead catfish and blue crab.	TCEQ	H. Rifai
Total Maximum Daily Loads for PCBs in the HSC	2008-2010	Due to the health advisory for PCBs for the HSC. Continued work on a total maximum daily load (TMDL) allocation for PCBs in the HSC System was conducted in 2008 and 2009.	In 2008-2009, only PCB congeners were analyzed in fish, including hardhead catfish. Data are presented in quarterly reports published between 2008 -2010.	TCEQ	H. Rifai and R. Palachek

Table 2-2
Summary of Bulk Sediment Chemistry Datasets

Sediment Investigation Purpose	Number of Stations Sampled	Number of Samples Collected	Sample Depth Interval	Analyses	Notes
Vertical Sediment Characterization	14	87	The first sample interval of the core was 0-11 cm. Subsequent intervals were approximately 30 cm.	Metals, mercury, PCDD/PCDFs, PAHs, pesticides, SVOCs, VOCs, PCB Aroclors, PCB congeners, TOC, total solids, grain size.	Total core lengths ranged from 7 to 226 cm. Co-located surface grabs collected from 0-2 cm.
Upstream Characterization	2006: 4 2011: 5	2006: 4 2011: 7	2006: 0-2 cm 2011: At 4 stations the sample interval was 0-10 cm. At the fifth station, samples were collected in 30 cm intervals from 0-90 cm.	2006: Metals, mercury, PCB Aroclors, PAHs, SVOCs, VOCs, pesticides, TOC, total solids 2011: grain size, TOC, specific gravity, metals, PAHs, PCB congeners, PCDD/PCDFs.	
Mixing Zone	10	59	Samples were collected in 2 cm intervals at five depths from 0-20 cm.	PCB Aroclors, mercury, HCBD, PAHs, TOC, density, total solids, grain size.	Sample intervals were: 0-2 cm, 4-6 cm, 8-10 cm, 12-14 cm, and 16-18 cm. The entire core was composited for grain size analysis.
Lateral Characterization	2009: 47 2011: 6	2009: 47 2011: 6	0-10 cm	2009: grain size, TOC, ammonia, AVS/SEM, metals, PAHs, SVOCs, VOCs, PCB congeners, pesticides, PCDD/PCDFs 2011: PCB Aroclors, PAHs.	The AVS/SEM samples were collected from 0-2 cm.

Notes:
SVOC - semi-volatile organic compound
PAH - polycyclic aromatic hydrocarbon
VOC - volatile organic compound
PCB - polychlorinated biphenyl
PCDD/PCDF - polychlorinated dibenzo-p-dioxin/polychlorinated dibenzofuran
TOC - total organic carbon
HCBD - hexachlorobutadiene
AVS/SEM - acid volatile sulfides/simultaneously extracted metals

Table 2-3
Summary of Surface Water Chemistry Datasets

Surface Water Investigation	Number of Stations Sampled	Number of Samples Collected	Sample Depth	Analyses	Notes
November 2009 Event	7	22	Mid-depth of water column and 6 inches from bottom	SVOCs, PAHs, VOCs, pesticides, PCB congeners, PCDD/PCDFs, selenium and mercury (total and dissolved), TKN, conventional water quality parameters	Samples were collected during slack low tide and mid-tide (on an outgoing tide)
August 2011 Event	4	4	Mid-depth of water column	TOC, TSS, PCB congeners	Samples were collected during a slack to outgoing tide

Notes:
SVOC - semi-volatile organic compound
PAH - polycyclic aromatic hydrocarbon
VOC - volatile organic compound
PCB - polychlorinated biphenyl
PCDD/PCDF - polychlorinated dibenzo-p-dioxin/polychlorinated dibenzofuran
TKN - total Kjeldahl nitrogen
TOC - total organic carbon
TSS - total suspended solids

Table 2-4
Summary of Tissue Chemistry Datasets

Tissue Investigation	Sample Type	Number of Samples Collected	Species Collected	Analyses	Notes
BERA - June 2011	Fish	50	Gulf killifish, Gulf menhaden, pinfish, sand seatrout, striped mullet	Mercury, HCB, 1,3-dichlorobenzene, PCB congeners, PCDD/PCDFs	All fish collected were less than 15 cm total length
	Invertebrate	33	Blue crab, brown shrimp, white shrimp, oysters	Lead, mercury, PCB congeners, PCDD/PCDFs, PAH, HCB, HCBD, 1,3-dichlorobenzene, 1,4-dichlorobenzene	Two size classes were collected: 2-7.5 cm and 7.5 - 13 cm
BHHRA - September and October 2011	Fish	33	Hardhead catfish	PCDD/PCDFs, PCB congeners	All fish collected were greater than 30 cm total length, edible tissue only
	Invertebrate	20	Blue crab	PCDD/PCDFs, PCB congeners	All crabs collected had carapace width greater than 30 cm, edible tissue only

Notes:
HCB - hexachlorobenzene
PCB - polychlorinated biphenyl
PCDD/PCDF - polychlorinated dibenzo-p-dioxin/polychlorinated dibenzofuran
PAH - polycyclic aromatic hydrocarbon
HCBD - hexachlorobutadiene

Table 3-1
Vertical Variation in Erosion Rate Parameters

Depth Interval	Proportionality Constant: A	Exponent: n	Critical Shear Stress (Pa)
0 – 6 cm	0.0046	2.5	0.21
6 – 11 cm	0.0016	2.7	0.38
11 – 16 cm	0.0017	2.7	0.35
16 – 21 cm	0.0010	3.1	0.49
21 – 26 cm	0.0009	3.1	0.49

Table 4-1
Summary of Site Sediment Results

	Number of Samples	Number of Nondetected Sample	Minimum Non-Detection	Maximum Non-Detection	Number of Detected Sample	Minimum Detection	Maximum Detection	Average Detection	Average of All Results*
Metals (mg/kg)									
Lead	60	0	--	--	60	9.72	335	63.1	63.1
Semivolatile Organics (ug/kg)									
bis(2-Ethylhexyl)phthalate	60	5	2000	12000	55	132	11800	1630	1670
PCB Congeners (mg/kg)									
Total Decachlorobiphenyl homologs (U = 1/2)	60	1	0.000592	0.000592	59	0.000017	117	3.43	3.43
Total Dichlorobiphenyl homologs (U = 1/2)	60	0	--	--	60	0.000585	4.37	0.189	0.189
Total Heptachlorobiphenyl homologs (U = 1/2)	60	0	--	--	60	0.00173	0.457	0.116	0.116
Total Hexachlorobiphenyl homologs (U = 1/2)	60	0	--	--	60	0.00219	2.78	0.426	0.426
Total Monochlorobiphenyl homologs (U = 1/2)	60	0	--	--	60	0.0000394	0.572	0.0265	0.0265
Total Nonachlorobiphenyl homologs (U = 1/2)	60	0	--	--	60	0.000079	2.76	0.0673	0.0673
Total Octachlorobiphenyl homologs (U = 1/2)	60	0	--	--	60	0.00043	0.634	0.0376	0.0376
Total Pentachlorobiphenyl homologs (U = 1/2)	60	0	--	--	60	0.00179	17.2	1.63	1.63
Total Tetrachlorobiphenyl homologs (U = 1/2)	60	0	--	--	60	0.00229	48.5	3.56	3.56
Total Trichlorobiphenyl homologs (U = 1/2)	60	0	--	--	60	0.00124	21.0	1.59	1.59
Total PCB Congener (U = 1/2)	60	0	--	--	60	0.0109	124	11.1	11.1
Polycyclic Aromatic Hydrocarbons (mg/kg)									
Total HPAH (9 of 16) (U = 1/2)	66	0	--	--	66	0.00833	168	21.0	21.0
Total LPAH (7 of 16) (U = 1/2)	66	0	--	--	66	0.00808	1138	33.3	33.3
Total PAH (16) (U = 1/2)	66	0	--	--	66	0.0164	1307	54.3	54.3

Notes:

*Average of all results, including non-detects, which are reported at ½ the non-detect result

µg/kg = micrograms per kilogram

mg/kg = milligrams per kilogram

Totals are calculated as the sum of all detected results and half of the **detection limit** of undetected results (U=1/2).

Total LPAH (Low PAH) are the total of Naphthalene, Acenaphthylene, Acenaphthene, Fluorene, Phenanthrene, Anthracene, and 2-Methylnapthalene

Total HPAH (High PAH) are the total of Fluoranthene, Pyrene, Benzo(a)anthracene, Chrysene, Benzofluoranthenes, Benzo(a)pyrene, Indeno(1,2,3-c,d)pyrene, Dibenzo(a,h)anthracene and Benzo(g,h,i)perylene

Total PAH are the total of Naphthalene, Acenaphthylene, Acenaphthene, Fluorene, Phenanthrene, Anthracene, Fluoranthene, Pyrene, Benzo(a)anthracene, Chrysene, Benzofluoranthenes, Benzo(a)pyrene, Indeno(1,2,3-c,d)pyrene, Dibenzo(a,h)anthracene and Benzo(g,h,i)perylene, and 2-Methylnapthalene

Table 4-2
Summary of Surface Sediment Results Upstream of the Site

	Number of Samples	Number of Nondetected Sample	Minimum Non-Detection	Maximum Non-Detection	Number of Detected Sample	Minimum Detection	Maximum Detection	Average Detection	Average of All Results*
Metals (mg/kg)									
Lead	11	0	--	--	11	7.29	201	48.3	48.3
PCB Congeners (mg/kg)									
Total Decachlorobiphenyl homologs (U = 1/2)	7	0	--	--	7	0.0000100	0.000268	0.0000969	0.0000969
Total Dichlorobiphenyl homologs (U = 1/2)	7	0	--	--	7	0.000105	0.000530	0.000279	0.000279
Total Heptachlorobiphenyl homologs (U = 1/2)	7	0	--	--	7	0.000572	0.00274	0.00154	0.00154
Total Hexachlorobiphenyl homologs (U = 1/2)	7	0	--	--	7	0.00167	0.00513	0.00312	0.00312
Total Monochlorobiphenyl homologs (U = 1/2)	7	6	0.000002	0.000005	1	0.0000130	0.0000130	0.0000130	0.0000035
Total Nonachlorobiphenyl homologs (U = 1/2)	7	0	--	--	7	0.0000190	0.0000920	0.0000556	0.0000556
Total Octachlorobiphenyl homologs (U = 1/2)	7	0	--	--	7	0.000130	0.000700	0.000391	0.000391
Total Pentachlorobiphenyl homologs (U = 1/2)	7	0	--	--	7	0.00229	0.00572	0.00339	0.00339
Total Tetrachlorobiphenyl homologs (U = 1/2)	7	0	--	--	7	0.00111	0.00497	0.00266	0.00266
Total Trichlorobiphenyl homologs (U = 1/2)	7	0	--	--	7	0.000223	0.00355	0.00166	0.00166
Total PCB Congener (U = 1/2)	7	0	--	--	7	0.00838	0.0174	0.0132	0.0132
Polycyclic Aromatic Hydrocarbons (mg/kg)									
Total HPAH (9 of 16) (U = 1/2)	11	0	--	--	11	0.410	46.4	11.9	11.9
Total LPAH (7 of 16) (U = 1/2)	11	0	--	--	11	0.0630	5.07	1.42	1.42
Total PAH (16) (U = 1/2)	11	0	--	--	11	0.473	51.5	13.3	13.3

Notes:
*Average of all results, including non-detects, which are reported at ½ the non-detect result
mg/kg = milligrams per kilogram
Totals are calculated as the sum of all detected results and half of the detection limit of undetected results (U=1/2).
Total LPAH (Low PAH) are the total of Naphthalene, Acenaphthylene, Acenaphthene, Fluorene, Phenanthrene, Anthracene, and 2-Methylnapthalene
Total HPAH (High PAH) are the total of Fluoranthene, Pyrene, Benzo(a)anthracene, Chrysene, Benzofluoranthenes, Benzo(a)pyrene, Indeno(1,2,3-c,d)pyrene, Dibenzo(a,h)anthracene and Benzo(g,h,i)perylene
Total PAH are the total of Naphthalene, Acenaphthylene, Acenaphthene, Fluorene, Phenanthrene, Anthracene, Fluoranthene, Pyrene, Benzo(a)anthracene, Chrysene, Benzofluoranthenes, Benzo(a)pyrene, Indeno(1,2,3-c,d)pyrene, Dibenzo(a,h)anthracene and Benzo(g,h,i)perylene, and 2-Methylnapthalene

Table 4-3
Summary of Porewater Results

	Number of Samples	Number of Nondetected Sample	Minimum Non-Detection	Maximum Non-Detection	Number of Detected Sample	Minimum Detection	Maximum Detection	Average Detection	Average of All Results*
Metals, Dissolved (porewater) (µg/L)									
Lead	10	10	0.064	0.619	0	--	--	--	0.219
Semivolatile Organic Compounds (µg/L)									
Bis(2-ethylhexyl)phthalate	10	0	--	--	10	1	180	58.3	58.3
PCB Congeners (porewater) (ug/L)									
Total Decachlorobiphenyl homologs (U = 1/2)	10	0	--	--	10	0.0131	87	9.06	9.06
Total Dichlorobiphenyl homologs (U = 1/2)	10	0	--	--	10	0.0110	203	20.4	20.4
Total Heptachlorobiphenyl homologs (U = 1/2)	10	0	--	--	10	0.0820	124	12.9	12.9
Total Hexachlorobiphenyl homologs (U = 1/2)	10	0	--	--	10	0.142	238	24.4	24.4
Total Monochlorobiphenyl homologs (U = 1/2)	10	2	0.004	0.004	8	0.00099	26.8	3.36	2.69
Total Nonachlorobiphenyl homologs (U = 1/2)	10	0	--	--	10	0.00826	4.03	0.428	0.428
Total Octachlorobiphenyl homologs (U = 1/2)	10	0	--	--	10	0.0390	25.8	2.68	2.68
Total Pentachlorobiphenyl homologs (U = 1/2)	10	0	--	--	10	0.316	1325	135	135
Total Tetrachlorobiphenyl homologs (U = 1/2)	10	0	--	--	10	0.592	3038	309	309
Total Trichlorobiphenyl homologs (U = 1/2)	10	0	--	--	10	0.228	2039	206	206
Total PCB Congener (U = 1/2)	10	0	--	--	10	1.56	7111	722	722
Polycyclic Aromatic Hydrocarbons (porewater) (ug/L)									
Total HPAH (9 of 16) (U = 1/2)	10	0	--	--	10	1.07	5720	838	838
Total LPAH (7 of 16) (U = 1/2)	10	0	--	--	10	0.869	13900	2049	2049
Total PAH (16) (U = 1/2)	10	0	--	--	10	1.98	19620	2887	2887

Notes:
*Average of all results, including non-detects, which are reported at ½ the non-detect result
µg/L = micrograms per liter
Totals are calculated as the sum of all detected results and half of the **detection limit** of undetected results (U=1/2).
Total LPAH (Low PAH) are the total of Naphthalene, Acenaphthylene, Acenaphthene, Fluorene, Phenanthrene, Anthracene, and 2-Methylnapthalene
Total HPAH (High PAH) are the total of Fluoranthene, Pyrene, Benzo(a)anthracene, Chrysene, Benzofluoranthenes, Benzo(a)pyrene, Indeno(1,2,3-c,d)pyrene, Dibenzo(a,h)anthracene and Benzo(g,h,i)perylene
Total PAH are the total of Naphthalene, Acenaphthylene, Acenaphthene, Fluorene, Phenanthrene, Anthracene, Fluoranthene, Pyrene, Benzo(a)anthracene, Chrysene, Benzofluoranthenes, Benzo(a)pyrene, Indeno(1,2,3-c,d)pyrene, Dibenzo(a,h)anthracene and Benzo(g,h,i)perylene, and 2-Methylnapthalene

Table 4-4
Summary of Surface Water Results

	Number of Samples	Number of Nondetected Sample	Minimum Non-Detection	Maximum Non-Detection	Number of Detected Sample	Minimum Detection	Maximum Detection	Average Detection	Average of All Results*
PCB Congeners (ug/L)									
Total Decachlorobiphenyl homologs (U = 1/2)	26	2	0.000009	0.000012	24	0.0000440	0.00952	0.00209	0.00193
Total Dichlorobiphenyl homologs (U = 1/2)	26	0	--	--	26	0.0000630	0.00831	0.00160	0.00160
Total Heptachlorobiphenyl homologs (U = 1/2)	26	0	--	--	26	0.0000680	0.00401	0.00134	0.00134
Total Hexachlorobiphenyl homologs (U = 1/2)	26	0	--	--	26	0.000190	0.0172	0.00464	0.00464
Total Monochlorobiphenyl homologs (U = 1/2)	26	1	0.00001	0.00001	25	0.0000100	0.000210	0.0000453	0.0000437
Total Nonachlorobiphenyl homologs (U = 1/2)	26	7	0.000008	0.000012	19	0.00000700	0.000609	0.000199	0.000146
Total Octachlorobiphenyl homologs (U = 1/2)	26	2	0.000024	0.000024	24	0.0000200	0.000850	0.000331	0.000307
Total Pentachlorobiphenyl homologs (U = 1/2)	26	0	--	--	26	0.000300	0.0879	0.0195	0.0195
Total Tetrachlorobiphenyl homologs (U = 1/2)	26	0	--	--	26	0.000240	0.211	0.0475	0.0475
Total Trichlorobiphenyl homologs (U = 1/2)	26	0	--	--	26	0.000120	0.101	0.0218	0.0218
Total PCB Congener (U = 1/2)	26	0	--	--	26	0.00128	0.431	0.0989	0.0989

Notes:
*Average of all results, including non-detects, which are reported at ½ the non-detect result
µg/L = micrograms per liter
Totals are calculated as the sum of all detected results and half of the **detection limit** of undetected results (U=1/2).

Table 4-5
Summary of Sediment Trap Results

	Number of Samples	Number of Nondetected Sample	Minimum Non-Detection	Maximum Non-Detection	Number of Detected Sample	Minimum Detection	Maximum Detection	Average Detection	Average of All Results*
Metals (mg/kg)									
Lead	11	0	--	--	11	22.9	50.2	35.6	35.6
Semivolatile Organics (µg/kg)									
bis(2-Ethylhexyl)phthalate	11	0	--	--	11	170	2700	1320	1320
PCB Congeners (mg/kg)									
Total Decachlorobiphenyl homologs (U = 1/2)	11	0	--	--	11	0.000141	0.0114	0.00388	0.00388
Total Dichlorobiphenyl homologs (U = 1/2)	11	0	--	--	11	0.00118	0.0322	0.0100	0.0100
Total Heptachlorobiphenyl homologs (U = 1/2)	11	0	--	--	11	0.00223	0.0702	0.0193	0.0193
Total Hexachlorobiphenyl homologs (U = 1/2)	11	0	--	--	11	0.00472	0.192	0.0532	0.0532
Total Monochlorobiphenyl homologs (U = 1/2)	11	0	--	--	11	0.0000590	0.000650	0.000252	0.000252
Total Nonachlorobiphenyl homologs (U = 1/2)	11	0	--	--	11	0.0000250	0.00200	0.000615	0.000615
Total Octachlorobiphenyl homologs (U = 1/2)	11	0	--	--	11	0.000410	0.0149	0.00445	0.00445
Total Pentachlorobiphenyl homologs (U = 1/2)	11	0	--	--	11	0.0104	0.850	0.241	0.241
Total Tetrachlorobiphenyl homologs (U = 1/2)	11	0	--	--	11	0.00792	1.77	0.519	0.519
Total Trichlorobiphenyl homologs (U = 1/2)	11	0	--	--	11	0.00709	0.770	0.192	0.192
Total PCB Congener (U = 1/2)	11	0	--	--	11	0.0465	3.72	1.04	1.04
Polycyclic Aromatic Hydrocarbons (mg/kg)									
Total HPAH (9 of 16) (U = 1/2)	11	0	--	--	11	0.856	13.1	5.52	5.52
Total LPAH (7 of 16) (U = 1/2)	11	0	--	--	11	0.0742	3.51	1.07	1.07
Total PAH (16) (U = 1/2)	11	0	--	--	11	0.930	15.9	6.60	6.60

Notes:
*Average of all results, including non-detects, which are reported at ½ the non-detect result
mg/kg = milligrams per kilogram
µg/kg = microgram per kilogram
Totals are calculated as the sum of all detected results and half of the **detection limit** of undetected results (U=1/2).
Total LPAH (Low PAH) are the total of Naphthalene, Acenaphthylene, Acenaphthene, Fluorene, Phenanthrene, Anthracene, and 2-Methylnapthalene.
Total HPAH (High PAH) are the total of Fluoranthene, Pyrene, Benzo(a)anthracene, Chrysene, Benzofluoranthenes, Benzo(a)pyrene, Indeno(1,2,3-c,d)pyrene, Dibenzo(a,h)anthracene and Benzo(g,h,i)perylene.
Total PAH are the total of Naphthalene, Acenaphthylene, Acenaphthene, Fluorene, Phenanthrene, Anthracene, Fluoranthene, Pyrene, Benzo(a)anthracene, Chrysene, Benzofluoranthenes, Benzo(a)pyrene, Indeno(1,2,3-c,d)pyrene, Dibenzo(a,h)anthracene and Benzo(g,h,i)perylene, and 2-Methylnapthalene.

Table 4-6
Summaries of Edible Tissue Results for Blue Crab and Hardhead Catfish

Chemical	Number of Samples	Number of Nondetected Sample	Minimum Non-Detection	Maximum Non-Detection	Number of Detected Sample	Minimum Detection	Maximum Detection	Average Detection	Average of All Results*
BLUE CRAB									
PCB Congeners (ug/kg)									
Total PCB Congener (U = 1/2)	20	0	--	--	20	19.6	377	112	112
PCB Congeners (ng/kg)									
Total PCB Congener TEQ 2005 (Mammal) (U = 1/2)	20	0	--	--	20	0.340	8.07	3.18	3.18
HARDHEAD CATFISH									
PCB Congeners (ug/kg)									
Total PCB Congener (U = 1/2)	30	0	--	--	30	187	5360	1440	1440
PCB Congeners (ng/kg)									
Total PCB Congener TEQ 2005 (Mammal) (U = 1/2)	30	0	--	--	30	3.30	85.6	24.6	24.6

Notes:
*Average of all results, including non-detects, which are reported at ½ the non-detect result
µg/kg = micrograms per kilogram
ng/kg = nanograms per kilogram
Totals are calculated as the sum of all detected results and half of the detection limit of undetected results (U=1/2).

Table 4-7
Summaries of Whole Body Tissue Results for Sampled Species and Average Chemical Concentrations

Chemical	Number of Samples	Number of Nondetected Sample	Minimum Non-Detection	Maximum Non-Detection	Number of Detected Sample	Minimum Detection	Maximum Detection	Average Detection	Average of All Results*
BLUE CRAB - SIZE CLASS A									
PCB Congeners (ug/kg)									
Total PCB Congener (U = 1/2)	18	0	--	--	18	229	1260	655	655
PCB Congeners (ng/kg)									
Total PCB Congener TEQ 1998 (Avian) (U = 1/2)	18	0	--	--	18	97.6	783	363	363
Total PCB Congener TEQ 2005 (Mammal) (U = 1/2)	18	0	--	--	18	8.35	49.2	24.8	24.8
BLUE CRAB - SIZE CLASS B									
PCB Congeners (ug/kg)									
Total PCB Congener (U = 1/2)	3	0	--	--	3	229	1260	677	677
PCB Congeners (ng/kg)									
Total PCB Congener TEQ 1998 (Avian) (U = 1/2)	3	0	--	--	3	434	509	476	476
Total PCB Congener TEQ 2005 (Mammal) (U = 1/2)	3	0	--	--	3	30.8	43.1	35.6	35.6
BROWN SHRIMP - SIZE CLASS B									
PCB Congeners (ug/kg)									
Total PCB Congener (U = 1/2)	8	0	--	--	8	997	2190	1720	1720
PCB Congeners (ng/kg)									
Total PCB Congener TEQ 1998 (Avian) (U = 1/2)	8	0	--	--	8	370	695	533	533
Total PCB Congener TEQ 2005 (Mammal) (U = 1/2)	8	0	--	--	8	8.20	41.2	24.8	24.8
GULF KILLIFISH									
PCB Congeners (ug/kg)									
Total PCB Congener (U = 1/2)	25	0	--	--	25	1960	8850	5220	5220
PCB Congeners (ng/kg)									
Total PCB Congener TEQ 1998 (Avian) (U = 1/2)	25	0	--	--	25	271	1170	795	795
Total PCB Congener TEQ 2005 (Mammal) (U = 1/2)	25	0	--	--	25	15.6	137	77.4	77.4
GULF MENHADEN									
PCB Congeners (ug/kg)									
Total PCB Congener (U = 1/2)	10	0	--	--	10	1260	4010	2640	2640
PCB Congeners (ng/kg)									
Total PCB Congener TEQ 1998 (Avian) (U = 1/2)	10	0	--	--	10	197	789	449	449
Total PCB Congener TEQ 2005 (Mammal) (U = 1/2)	10	0	--	--	10	12.9	46.6	31.2	31.2
OYSTER - SIZE CLASS A									
PCB Congeners (ug/kg)									
Total PCB Congener (U = 1/2)	1	0	--	--	1	1430	1430	1430	1430
PCB Congeners (ng/kg)									
Total PCB Congener TEQ 1998 (Avian) (U = 1/2)	1	0	--	--	1	361	361	361	361
Total PCB Congener TEQ 2005 (Mammal) (U = 1/2)	1	0	--	--	1	20.7	20.7	20.7	20.7
PINFISH									
PCB Congeners (ug/kg)									
Total PCB Congener (U = 1/2)	4	0	--	--	4	2110	4330	3160	3160
PCB Congeners (ng/kg)									
Total PCB Congener TEQ 1998 (Avian) (U = 1/2)	4	0	--	--	4	89.6	148	121	121
Total PCB Congener TEQ 2005 (Mammal) (U = 1/2)	4	0	--	--	4	24.0	51.4	36.2	36.2

Table 4-7
Summaries of Whole Body Tissue Results for Sampled Species and Average Chemical Concentrations

Chemical	Number of Samples	Number of Nondetected Sample	Minimum Non-Detection	Maximum Non-Detection	Number of Detected Sample	Minimum Detection	Maximum Detection	Average Detection	Average of All Results*
SAND SEATROUT									
PCB Congeners (ug/kg)									
Total PCB Congener (U = 1/2)	2	0	--	--	2	1450	2510	1980	1980
PCB Congeners (ng/kg)									
Total PCB Congener TEQ 1998 (Avian) (U = 1/2)	2	0	--	--	2	77.5	188	133	133
Total PCB Congener TEQ 2005 (Mammal) (U = 1/2)	2	0	--	--	2	3.63	25.9	14.8	14.8
STRIPED MULLET									
PCB Congeners (ug/kg)									
Total PCB Congener (U = 1/2)	9	0	--	--	9	596	4540	2250	2250
PCB Congeners (ng/kg)									
Total PCB Congener TEQ 1998 (Avian) (U = 1/2)	9	0	--	--	9	104	789	356	356
Total PCB Congener TEQ 2005 (Mammal) (U = 1/2)	9	0	--	--	9	4.26	51.5	21.6	21.6
WHITE SHRIMP - SIZE CLASS A									
PCB Congeners (ug/kg)									
Total PCB Congener (U = 1/2)	1	0	--	--	1	837	837	837	837
PCB Congeners (ng/kg)									
Total PCB Congener TEQ 1998 (Avian) (U = 1/2)	1	0	--	--	1	277	277	277	277
Total PCB Congener TEQ 2005 (Mammal) (U = 1/2)	1	0	--	--	1	18.1	18.1	18.1	18.1
WHITE SHRIMP - SIZE CLASS B									
PCB Congeners (ug/kg)									
Total PCB Congener (U = 1/2)	2	0	--	--	2	548	919	734	734
PCB Congeners (ng/kg)									
Total PCB Congener TEQ 1998 (Avian) (U = 1/2)	2	0	--	--	2	177	312	245	245
Total PCB Congener TEQ 2005 (Mammal) (U = 1/2)	2	0	--	--	2	9.30	16.7	13.0	13.0

Notes:
*Average of all results, including non-detects, which are reported at ½ the non-detect result
µg/kg = micrograms per kilogram
ng/kg = nanograms per kilogram
Totals are calculated as the sum of all detected results and half of the **detection limit** of undetected results (U=1/2).

Table 5-1

Descriptions of Outfalls Related to the Patrick Bayou Site

Outfall	Description
Lubrizol Outfalls	
001	Treated process wastewater discharging into the culvert running between Deer Park and upper reach (start of gunite)
002	Stormwater discharge discharging at the mouth of the culvert exit in the upper reach
003	Stormwater discharge discharging approximately 1/3 of distance from the culvert exit to end of gunite
004	Stormwater discharge discharging approximately 4/5 of distance from the culvert exit to end of gunite
005	Stormwater discharge discharging approximately 4/5 of distance from the culvert exit to end of gunite
006	Stormwater discharge discharging into the culvert running between Deer Park and upper reach (start of gunite)
007	Stormwater discharge discharging into the East Fork of Patrick Bayou at northeast corner of Lubrizol property
Shell Outfalls	
C101/001	001 -Maintenance outfall (intermittent), 101 -Excess stormwater outfall discharging into Patrick Bayou
C002	Stormwater and domestic wastewater discharging into Patrick Bayou
C003	Stormwater and domestic wastewater discharging into Patrick Bayou
R-001	Utility wastewater and stormwater discharging into Patrick Bayou
R-002	Stormwater and non-process wastewater discharging into Patrick Bayou
R-003	Stormwater and non-process wastewater discharging into Patrick Bayou
R-004	Stormwater and fire water discharging into Patrick Bayou
R-009	Stormwater and fire water discharging into Patrick Bayou
OxyChem Outfalls	
001	Currently inactive; outfall was closed in 2010
002	Non-contact flow-through water from Houston Ship Channel outfall, outfall discharging into Patrick Bayou approximately 4,300 feet from mouth of the bayou
003	Non-contact flow-through water from Houston Ship Channel outfall, outfall discharging into Patrick Bayou approximately 3,600 feet from mouth of the bayou
Other Outfalls	
Deer Park WWTP -001	City of Deer Park wastewater treatment discharge; discharging to drainage ditch that flows to Patrick Bayou south of State

Table 5-1

Descriptions of Outfalls Related to the Patrick Bayou Site

Outfall	Description
	Highway 225
Praxair, Inc. -001	Utility wastewater that discharges to unnamed ditch that flows to East Fork of Patrick Bayou
Rohm-Haas -003	Non-process area stormwater that discharges to the East Fork of Patrick Bayou

Notes:

WWTP = Wastewater Treatment Plant

Table 6-1
Fate and Transport Chemical Properties of Indicator Chemicals

Indicator Chemical	Chemical Abstracts Service Number	Water Solubility (milligrams/liter) Value or Range	Source	Partition Coeficient* (liters/kilogram) Value or Range		Source	Biodgradation Rate (half life, days) Aerobic Value or Range	Source	Anaerobic Value or Range	Source
Polychlorinated Biphenyl Compounds (PCBs)										
Aroclor 1248	12672-29-6	4.30E-02 - 3.20E-01	5.	3.16E+04 - 7.66E+04	K_{oc}	13.	Not Available		Not Available	
PCB-209	2051-24-3	7.43E-06 - 6.32E-05	5.	4.41E+05 - 1.63E+06	K_{oc}	13.	Not Available		Not Available	
Tri-substituted PCBs	25323-68-6	3.91E-01 - 4.00E-01	5.	1.38E+04 - 4.86E+04	K_{oc}	13.	2 - 6	8.[C]	Not Available	
Tetra-substituted PCBs	26914-33-0	1.50E-02 - 8.60E-02	5.	2.74E+04 - 1.32E+05	K_{oc}	13.	4 - 56	8.[C]	Not Available	
Polycyclic Aromatic Hydrocarbons										
Acenaphthene	83-32-9	3.57E+00	7.	3.89E+03	K_{oc}	7.	1 - 7	9.	4 - 28	9.
Anthracene	120-12-7	4.34E-02	9.	1.58E+04	K_{oc}	7.	50 - 460	9.	200 - 1,840	9.
Benzo(a)anthracene	56-55-3	9.40E-03	9.	2.00E+05	K_{oc}	7.	102 - 680	6.[D]	408 - 2,720	6.[D]
Benzo(a)pyrene	50-32-8	1.62E-03	7.	5.07E+06	K_{oc}	7.	57 - 530	9.	228 - 2,120	9.
Benzo(b)fluoranthene	205-99-2	1.50E-03	9.	1.56E+05	K_{oc}	7.	360 - 610	6.[D]	1,440 - 2,440	6.[D]
Benzo(k)fluoranthene	207-08-9	8.00E-04	9.	2.20E+04	K_{oc}	7.	910 - 2,140	6.[D]	3,640 - 8,560	6.[D]
Chrysene	218-01-9	1.60E-03	9.	1.33E+05	K_{oc}	7.	371 - 1,000	6.[D]	1,484 - 4,000	6.[D]
Dibenz(a,h)anthracene	53-70-3	2.49E-03	9.	3.80E+06	K_{oc}	9.	361 - 940	6.[D]	Not Available	
Fluoranthene	206-44-0	2.06E-01	9.	4.20E+04	K_{oc}	7.	140 - 440	6.[D]	560 - 1,760	6.[D]
Fluorene	86-73-7	1.98E+00	9.	1.38E+04	K_{oc}	9.	32 - 60	6.[D]	128 - 240	6.[D]
Indeno(1 ,2,3-cd)pyrene	193-39-5	2.20E-05	9.	1.60E+06	K_{oc}	7.	Not Available		Not Available	
Naphthalene	91-20-3	3.10E+01	9.	8.70E+02	K_{oc}	7.	0.2 - 17	7.	NOD - NOD	7.
Pyrene	129-00-0	1.35E-01	9.	1.05E+05	K_{oc}	9.	210 - 1,900	6.[D]	840 - 7,600	6.[D]
Other Organic Indicator Chemicals										
Bis(2-ethylhexyl)phthalate	117-81-7	3.40E-01	9.	8.74E+04	K_{oc}	7.	5 - 23	9.	41 - 389	9.
Inorganic Indicator Chemicals										
Mercury	7439-97-6	5.60E-02[A]	14.	3.98E+03	k_d	11.	Not applicable		Not applicable	
Lead	7439-92-1	<0.05 (pH >7)[A]	12.	5.01E+03	k_d	11.	Not applicable		Not applicable	

Notes

* Partition Coefficients are the ratio of the concentration adsobed to the solid medium (in milligrams of constituent/kilogram of solid) to the concentration in water (in milligrams of constituent/liter of water). The resulting units for K_d or K_{oc} are liters/kilogram. For organic indicator chemicals, partitioning coefficients are adjusted for organic carbon content (K_{oc}).

NOD - No observed degradation

A. Solubility of metals in water is highly dependent on water chemistry, which affects the speciation of the metal. Mercury solubility is controlled by the presence of sulfide radicals and organic matter (Source 2). Lead is reported as insoluble in water at neutral and higher pH. Lead forms insoluble precipitates with carbonate, sulfide, sulfate, and phosphate radicals (Source 13).

B. Half life in sediment for PCBs generally. Degradation rates for individual congeners varies widely.

C. Half life values calculated from data presented in source.

Table 6-1
Fate and Transport Chemical Properties of Indicator Chemicals

D. Half lives converted from values given in hours. Aerobic degradation half lives measured in vadose-zone soil; anaerobic half lives measured in water.

E. Half lives converted from values given in hours. Degradation half lives measured in water.

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Table 7-1
Weight of Evidence Risk Characterization Summary for Benthic Invertebrates

Station	Proportion Toxic	Relative Mean PEL-Q	Relative Benthic Index	WOE Risk Characterization
V	0%	-33%	3.51	Indeterminate
2.5	0%	-9%	4.89	Low
S	0%	60%	5.25	Low
E	25%	9%	6.95	Low
U	0%	-92%	3.18	Indeterminate
3	31%	233%	6.82	Indeterminate
G	25%	-64%	6.12	Low
4A	54%	2327%	3.41	Probable
5	25%	40%	4.03	Indeterminate
T	0%	-26%	5.87	Low
6A	69%	441%	0.18	Probable
Q	25%	103%	2.49	Probable

Notes:

	Toxicity	Mean PEL-Q	Benthic Index
Low	<= 25% Toxic	Below Average	Above Average
Indeterminate	25-50% Toxic	Above Average	Below Average
Probable	> 50% Toxic	Highest 15%	Lowest 15%

Table 8-1
Potential ARAR Screening for the Patrick Bayou Superfund Site, Remedial Alternatives Technology Screening

Potential ARARs[1]	Citation	Summary	Comment
Federal			
Clean Water Act (CWA): Criteria and standards for imposing technology-based treatment requirements under §§ 309(b) and 402 of the Act	33 U.S.C. §§ 1319 and 1342 (implementing regulations at 40 CFR Part 125 Subpart A)	Both on-site and off-site discharges from CERCLA sites to surface waters are required to meet the substantive CWA (National Pollutant Discharge Elimination System) NPDES requirements (USEPA 1988).	On-site discharges must comply with the substantive technical requirements of the CWA but do not require a permit (USEPA 1988). Off-site discharges would be regulated under the conditions of a NPDES permit (USEPA 1988). Standards of control for direct discharges must meet technology-based requirements. Best conventional pollution control technology (BCT) is applicable to conventional pollutants. Best available technology economically achievable (BAT) applies to toxic and non-conventional pollutants. For CERCLA sites, BCT/BAT requirements are determined on a case-by-case basis using best professional judgment. This is likely to be a potential requirement only if treated water or excess dredge water is discharged during implementation.
CWA Sections 303 and 304: Federal Water Quality Criteria	33 U.S.C. §§1313 and 1314 (Most recent 304(a) list as updated to issuance of ROD)	Under §303 (33 U.S.C. §1313), individual States have established water quality standards to protect existing and attainable uses (USEPA 1988). CWA §301(b)(1)(C) requires that pollutants contained in direct discharges be controlled beyond BCT/BAT equivalents (USEPA 1988). CERCLA §121(d)(2)(B)(i) establishes conditions under which water quality criteria, which were developed by USEPA as guidance for States to establish location-specific water quality standards, are to be considered relevant and appropriate. Two kinds of water quality criteria have been developed under CWA §304 (33 U.S.C. §1314): one for protection of human health, and another for protection of aquatic life. These requirements include establishment of total maximum daily loads (TMDL).	The FS will consider the ability of remedial alternatives to satisfy established water quality criteria. Best management practices (BMPs) would be established for remedial actions and applied during construction. Water quality would also be monitored during construction and additional BMPs may be implemented if necessary to protect water quality. Where water quality State standards contain numerical criteria for toxic pollutants, appropriate numerical discharge limitations may be derived for the discharge and considered (USEPA 1988). Where State standards are narrative, either the whole-effluent or chemical-specific approach may generally be used as a standard of care (USEPA 1988).
CWA Section 307(b): Pretreatment Standards	33 U.S.C. §1317(b)	CERCLA §121(e) states that no Federal, State, or Local permit for direct discharges is required for the portion of any removal or remedial action conducted entirely on-site (the aerial extent of contamination and all suitable areas in close proximity to the contamination necessary for implementation of the response action) (USEPA 1988).	If off-site discharges from a CERCLA response activity were to enter receiving waters directly or indirectly, through treatment at a Publicly Owned Treatment Works (POTWs), they must comply with applicable Federal, State, and Local substantive requirements and formal administrative permitting requirements (USEPA 1988). This requirement may be triggered by disposal methods for waste.
CWA Section 401: Water Quality Certification	33 U.S.C. §1341	Requires applicants for Federal permits for projects that involve a discharge into navigable waters of the U.S. to obtain certification from State or regional regulatory agencies that the proposed discharge will comply with CWA Sections 301, 302, 303, 306, and 307.	Proposed activities that are on-site would not require a Federal permit. Therefore, certification is not legally required for on-site actions. Certification would be required for off-site actions. For on-site or off-site actions, certification should occur as part of the State identification of substantive State ARARs (USEPA 1988). Compliance with water quality criteria is discussed under CWA Sections 303 and 304.

[1] ARARs are applicable or relevant and appropriate requirements of Federal or State environmental laws and State facility siting laws. CERCLA section 121(d) requires that remedial actions generally comply with ARARs. The USEPA has stated a policy of attaining ARARs to the greatest extent practicable on remedial or removal actions (USEPA 1988). USEPA also stated that certain nonpromulgated Federal and State advisories or guidelines would be considered in selecting remedial or removal actions; these guidelines are referred to as TBCs, or "to be considered."

Table 8-1
Potential ARAR Screening for the Patrick Bayou Superfund Site, Remedial Alternatives Technology Screening

Potential ARARs[1]	Citation	Summary	Comment
CWA Section 404 and 404(b)(1): Dredge and Fill	33 U.S.C. §1344 (b)(1) (implementing regulations at 33 CFR 320 and 330; 40 CFR 230)	Discharges of dredged and fill material into waters of the U.S. must comply with the CWA §404 (33 U.S.C. 1344) guidelines and demonstrate the public interest is served (USEPA 1988).	Patrick Bayou is a water of the U.S. (USEPA 2007). Dredge and fill permits are applicable to dredging, in-water disposal, capping, construction of berms or levees, stream channelization, excavation and/or dewatering within waters of the U.S. (USEPA 1988). Permits are not required, however, for on-site CERCLA actions. Under the 404(b)(1) guidelines, efforts should be made to avoid, minimize, and mitigate adverse effects on the waters of the U.S. and, where possible, select a practicable (engineering feasible) alternative with the least adverse effects. The substantive requirements of Section 404 will be considered in the development and evaluation of remedial alternatives to minimize adverse impacts to waters of the U.S.
Safe Drinking Water Act	42 U.S.C. §300f (implementing regulations at 40 CFR Part 141, et seq.)	The Safe Drinking Water Act is applicable to public drinking water sources at the point of consumption ("at the tap"). Maximum contaminant levels (MCLs) have been established for certain constituents to protect human health and to preserve the aesthetic quality of public water supplies.	Safe Drinking Water Act standards are applicable to public drinking water sources. Patrick Bayou does not supply public drinking water and does not recharge an aquifer used to supply drinking water. Therefore, the Safe Drinking Water Act is not applicable. The MCL for 2,3,7,8-tetrachlorodibenzodioxin may be considered for protecting water quality.
Federal Drinking Water Regulations (Primary and Secondary Drinking Water Standards)[2]	40 CFR 141 and Part 143	USEPA has established two sets of drinking water standards: one for protection of human health (primary) and one to protect aesthetic values of drinking water (secondary) (USEPA 1988). MCLs are applicable to public drinking water sources at the point of consumption.	Safe Drinking Water Act standards are applicable to public drinking water sources. Patrick Bayou does not supply public drinking water and does not recharge an aquifer used to supply drinking water. Therefore, the Safe Drinking Water Act is not applicable. The MCL for 2,3,7,8-tetrachlorodibenzodioxin may be considered for protecting water quality.
Resource Conservation and Recovery Act (RCRA): Hazardous Waste Management	42 U.S.C. §§6921 et seq. (implementing regulations at 40 CFR Parts 260 – 268)	RCRA is intended to protect human health and the environment from the hazards posed by waste management (both hazardous and nonhazardous). RCRA also contains provisions to encourage waste reduction. RCRA Subtitle C and its implementing regulations contain the Federal requirements for the management of hazardous wastes.	This requirement would apply to certain activities if the affected sediments contain RCRA listed hazardous waste or exhibit a hazardous waste characteristic. RCRA requirements are applicable only if waste is managed (treated, stored, or disposed of) after effective date of RCRA requirement under consideration or if CERCLA activity constitutes treatment, storage, or disposal as defined by RCRA.
RCRA: General Requirements for Solid Waste Management	42 U.S.C. §§6941 et seq. (implementing regulations at 40 CFR 258)	Requirements for construction for municipal solid waste landfills that receive RCRA Subtitle D wastes, including industrial solid waste. Requirements for run-on/run-off control systems, groundwater monitoring systems, surface water requirements, etc.	This requirement would be relevant if a landfill was constructed for the disposal of non-hazardous solid waste. There are no specific Federal requirements for non-hazardous waste management; State regulations provide specific applicable requirements for siting, design, permitting, and operation of landfills.
Toxic Substances Control Act (TSCA)	15 U.S.C. §2601 et. seq. (implementing regulations at 40 CFR 761)	Potentially applicable to PCB-contaminated sediment or surface water. Requires remedial action of certain PCB releases depending on the concentration of the source material and the date of the release (or the as-found concentration for releases where the date is undetermined). Disposal and treatment requirements are also specified for environmental media if removed depending on total PCB concentrations.	Total PCB concentrations in limited areas of the Site may exceed the regulatory threshold (50 mg/kg, calculated as specified in 40 CFR 761) that would require remedial action and may trigger certain requirements for waste management. TSCA regulations may be insignificant relative to other bases for remedial action. No sediment samples contain total PCB concentrations that would trigger TSCA requirements for disposal by incineration.
Clean Air Act (CAA)	42 U.S.C. §§7401 et seq.	Would apply if dredging and/or excavation activities generate air emissions sufficient to require a permit, greater than 10 tons of any pollutant per year under the CAA operational permit (USEPA 2009).	None of the remedial alternatives is expected to trigger an operational permit.
Rivers And Harbors Act of 1899: Obstruction of navigable waters (generally, wharves; piers, etc.); excavation and filling-in	33 U.S.C. §401	Controls the alteration of navigable waters (i.e., waters subject to ebb and flow of the tide shoreward to the mean high water mark). Activities controlled include construction of structures such as piers, berms, and installation of pilings, as well as excavation and fill. Section 10 may be applicable for any action that may obstruct or alter a navigable waterway.	No permit is required for on-site activities. However, substantive requirements might limit in-water construction activities.

[2] Underground injection is not anticipated as a part of the potential remedial action. Furthermore, the site is not located in a sole-source aquifer (USEPA 2008). It is also assumed that no wellhead protection area is located near the study area.

Table 8-1
Potential ARAR Screening for the Patrick Bayou Superfund Site, Remedial Alternatives Technology Screening

Potential ARARs[1]	Citation	Summary	Comment
Endangered Species Act	16 U.S.C. §§ 1531 et seq.	Federal agencies must ensure that actions they authorize, fund, or carry out are not likely to adversely modify or destroy critical habitat of endangered or threatened species. Actions authorized, funded, or carried out by Federal agencies may not jeopardize the continued existence of endangered or threatened species, as well as adversely modify or destroy their critical habitats.	If Federally listed threatened or endangered (T&E) species or their critical habitat are present on the site or utilize areas in the vicinity of the site, this requirement is potentially relevant to determination of cleanup areas/volumes, preliminary remediation goals, and determination of removal alternatives. Based on review of USFWS and NMFS maps, no critical habitat is present at the site. Based on a review of photos and aerial images of the site and lists of federal T&E species and their habitats, it is unlikely that T&E species are present at the site, although some species may be present downstream in the Houston Ship Channel vicinity. Pursuant to CERCLA 121(e) and USEPA policy, separate consultation with the U.S. Fish and Wildlife Service (USFWS) and National Marine Fisheries Service (NMFS) is not required and permits are not required. USEPA will consult with the resource agencies.
Fish and Wildlife Coordination Act	16 U.S.C. §§661 et seq., 16 U.S.C. §742a, 16 U.S.C. § 2901	Requires adequate provision for protection of fish and wildlife resources. This title has been expanded to include requests for consultation with USFWS for water resources development projects (Mueller 1980). Any modifications to rivers and channels require consultation with the USFWS, Department of Interior, and state wildlife resources agency[3]. Project-related losses (including discharge of pollutants to water bodies) may require mitigation or compensation.	Applicable to any action that controls or modifies a body of water.
Bald and Golden Eagle Protection Act	16 U.S.C. §668a-d	Makes it unlawful to take, import, export, possess, buy, sell, purchase, or barter any bald or golden eagle, nest, or egg. "Take" is defined as pursuing, hunting, shooting, poisoning, wounding, killing, capturing, trapping and collecting, molesting, or disturbing.	This requirement is potentially relevant to CERCLA activities. No readily available information suggests bald or golden eagles frequent the project area; however, a qualified biologist would perform a site visit prior to a potential remedial action to confirm that bald and golden eagles do not frequent the project area.
Migratory Bird Treaty Act	16 U.S.C. §§703-712 (implementing regulations at 50 CFR §10.12)	Makes it unlawful to take, import, export, possess, buy, sell, purchase, or barter any migratory bird. "Take" is defined as pursuing, hunting, shooting, poisoning, wounding, killing, capturing, and trapping and collecting.	This requirement is potentially relevant to CERCLA activities. It is likely that suitable nesting or stopover habitat is present; however, a qualified biologist would perform a site visit prior to a potential remedial action to evaluate migratory bird presence within and near the project area.
Coastal Zone Management Act	16 U.S.C. §§1451 et seq. (implementing regulations at 15 CFR 930)	Federal activities must be consistent with, to the maximum extent practicable, State coastal zone management programs. Federal agencies must supply the State with a consistency determination (USEPA 1989).	Patrick Bayou lies within the Coastal Zone Boundary according to the Texas Coastal Management Plan (TCMP) prepared by the General Land Office (GLO). The FS will consider whether the remedial alternatives would affect (adversely or not) the coastal zone, the lead agency is required to determine whether the activity will be consistent with the State's CZMP (USEPA 1989). More information regarding the State requirements is provided under Texas Coastal Coordination Council (TCCC) Policies for Development in Critical Areas.
FEMA (Federal Emergency Management Agency), Department of Homeland Security (Operating Regulations)	42 U.S.C. 4001 et seq. (implementing regulations at 44 CFR Chapter 1)	Prohibits alterations to river or floodplains that may increase potential for flooding.	This requirement is relevant to CERCLA activities in floodplains and in the river because the project area is within a designated flood zone. The FS will include an assessment of the potential impacts of remedial alternatives on the floodplain.
National Flood Insurance Program (NFIP) Regulations	42 U.S.C. subchapter III, §§4101 et seq.	Provides Federal flood insurance to local authorities and requires that the local authorities not allow fill in the river that would cause an increase in water levels associated with floods.	A hydrologic evaluation will be performed to determine if remedial alternatives would have a significant impact on the water level during a flood.

[3] Texas Parks and Wildlife Department.

Table 8-1
Potential ARAR Screening for the Patrick Bayou Superfund Site, Remedial Alternatives Technology Screening

Potential ARARs[1]	Citation	Summary	Comment
Title 40: Protection of the Environment - Statement of Procedures on Floodplain Management and Wetlands Protection	40 CFR Part 6 App. A; Executive Orders (EO) 11988 and 11990	Requires Federal agencies to conduct their activities to avoid, if possible, adverse impacts associated with the destruction or modification of wetlands and occupation or modification of floodplains. Executive Orders 11988 and 11990 require Federal projects to avoid adverse effects and minimize potential harm to wetlands and within flood plains. The EO 11990 requires Federal agencies to avoid to the extent possible the long and short-term adverse impacts associated with the destruction or modification of wetlands and to avoid direct or indirect support of new construction in wetlands wherever there is a practicable alternative (USEPA 1994).	This requirement is potentially relevant to disposal or treatment activities in the upland as well as any in-water facilities that might displace floodwaters. Effects on the base flood, typically the 100-year or 1% probability flood, should be minimized to the maximum extent practicable (Code of Federal Regulations 1985 as amended). The agency also adopted a requirement that the substantive requirements of the Protection of Wetlands Executive Order must be met (USEPA 1994). Unavoidable impacts to wetlands must be mitigated (USEPA 1994)[4].
National Historic Preservation Act	16 U.S.C. §§ 470 et seq. (implementing regulations at 36 CFR 800)	Section 106 of this statute requires Federal agencies to consider effects of their undertakings on historic properties. Historic properties may include any district, site, building, structure, or object included in or eligible for the National Register of Historic Places (NRHP), including artifacts, records, and material remains related to such a property.	Because of the extensive disturbance to the site and minimal upland disturbance that will likely occur for the project, it is not likely that NRHP-eligible historic properties will be affected by eventual site remediation activities.
Noise Control Act	42 U.S.C. §§ 4901 et seq. (implementing regulations at 40 CFR Subchapter G §201 et seq.	Noise Control Act remains in effect but unfunded (USEPA 2010).	Noise is regulated at the state level. See Texas Penal Code under state ARARs.
Hazardous Materials Transportation Act	49 U.S.C. §§1801 et seq. (implementing regulations at 49 CFR. Subchapter C)	Establishes standards for packaging, documenting, and transporting hazardous materials.	This requirement would apply to remedial alternatives that involve transporting hazardous materials off-site for treatment or disposal.

[4] Each agency is expected to minimize the destruction, loss, or degradation of wetlands, and to preserve and enhance the natural and beneficial values of wetlands when implementing actions such as CERCLA sites (President of the United States 1977). If §404 of the Clean Water Act is considered an ARAR, then the 404(b)(1) guidelines established in a Memorandum of Understanding (MOU) between USEPA and Department of Army should be followed (USEPA 1994). When habitat is severely degraded, a mitigation ratio of 1:1 may be acceptable (USEPA 1994). However, any mitigation would be at the discretion of the agency and the USEPA may elect to orient mitigation towards "minimizing further adverse environmental impacts rather than attempting to recreate the wetlands original value on site or off site" (USEPA 1988).

Table 8-1
Potential ARAR Screening for the Patrick Bayou Superfund Site, Remedial Alternatives Technology Screening

Potential ARARs	Citation	Summary	Comment
State			
30 Texas Administrative Code (TAC) Part 1: Industrial Solid Waste and Municipal Hazardous Waste General Terms	30 TAC §§335.1 – 335.15	General Terms: Substantive requirements for the transportation of industrial solid and hazardous wastes; requirements for the location, design, construction, operation, and closure of solid waste management facilities.	Guidelines to promote the proper collection, handling, storage, processing, and disposal of industrial solid waste or municipal hazardous waste in a manner consistent with the purposes of Texas Health and Safety Code, Chapter 361. Solid nonhazardous waste provisions are applicable if material is transported to an upland disposal facility.
30 TAC Part 1: Industrial Solid Waste and Municipal Hazardous Waste: Notification	30 TAC Chapter 335 Subchapter P	Requires placement of warning signs in contaminated and hazardous areas if a determination is made by the executive director of the Texas Water Commission a potential hazard to public health and safety exists which will be eliminated or reduced by placing a warning sign on the contaminated property.	The FS will consider the need for additional warning signs and fencing as part of potential institutional controls that may be implemented as a component of the remedial alternatives.
30 TAC Part 1: Industrial Solid Waste and Municipal Hazardous Waste: Generators	30 TAC Chapter 335, Subchapter C	Standards for hazardous waste generators either disposing of waste on-site or shipping off-site with the exception of conditionally exempt small quantity generators. The definition of hazardous involves State and Federal standards.	The sediment at the site is not listed hazardous waste, do not contain listed hazardous waste, and do not meet any of the characteristics of hazardous waste. Therefore, the rules for hazardous waste are neither applicable nor relevant and appropriate.
Texas Surface Water Quality Standards	30 TAC §307.4-7, 10	These state regulations provide: • General narrative criteria • Anti-degradation Policy • Numerical criteria for pollutants • Numerical and narrative criteria for water-quality related uses (e.g., human use) • Site specific criteria for Patrick Bayou	Surface water quality standards are ARARs.
Texas Water Quality: Pollutant Discharge Elimination System (TPDES)	30 TAC §279.10	These State regulations require stormwater discharge permits for either industrial discharge or construction-related discharge. The State of Texas was authorized by USEPA to administer the NPDES program in Texas on September 14, 1998 (Texas Commission on Environmental Quality 2009).	The FS will evaluate the need for a discharge permit for off-site remedial actions.
Texas Water Quality: Water Quality Certification	30 TAC §279.10	These State regulations establish procedures and criteria for applying for, processing, and reviewing state certifications under CWA, §401. It is the purpose of this chapter, consistent with the Texas Water Code and the Federal CWA, to maintain the chemical, physical, and biological integrity of the State's waters.	The development and evaluation of remedial alternatives will include consideration of potential water-quality impacts, relevant to the Water Quality Certification in Texas. Although permits are not required for on-site CERCLA actions, water quality certification is relevant as part of identification of substantive State ARARs (USEPA 1988).
Texas Risk Reduction Program	30 TAC §350	Activated upon release of Chemicals of Concern (COC). The Risk Reduction Program uses a tiered approach incorporating risk assessment techniques to help focus investigations, to determine appropriate protective concentration levels for human health, and when necessary, for ecological receptors. Includes protective concentration levels.	TRRP describes separate tiered processes for establishing Protective Concentration Levels (PCL) for COCs that can remain in a medium and be protective of human and ecological receptors at the point of exposure. As the site-specific risk assessment identified potential risk only to wildlife and benthic invertebrates, ecological PCLs for the indicator chemicals will be considered in the development of remedial action levels to protect these receptors. TRRP human health PCLs are not considered TBCs given that no COCs were identified in the Baseline Human Health Risk Assessment.
Marl, Sand and Gravel Permit	31 TAC §69	Establishes procedures for the issuance of a permit for taking of sedimentary material (marl, sand, gravel, shell, mudshell) from public waters of the State.	This requirement is applicable if sedimentary materials are removed from the site as part of any remedial alternative. A permit may not be needed for activities occurring incidental to dredging under State or Federal law. Coordination with the Texas Parks and Wildlife Commission will occur based upon the specific boundaries and activities conducted as part of the remedial alternative.
Natural Resources Code, Antiquities Code of Texas	Texas Parks and Wildlife Commission Regulations 191.092-171	Requires that the Texas Historical Commission staff review any action that has the potential to disturb historic and archeological sites on public land. Actions that need review include any construction program that takes place on land owned or controlled by a state agency or a state political subdivision, such as a city or a county. Without local control, this requirement does not apply.	Disturbance of any archaeological or historic resources is unlikely due to the highly modified nature of the site and focus of action within the sediments as opposed to upland areas. Depending on the magnitude and specific boundaries of ground disturbance determined during the FS for the overall site, this ARAR may need to be re-evaluated.

Table 8-1
Potential ARAR Screening for the Patrick Bayou Superfund Site, Remedial Alternatives Technology Screening

Potential ARARs	Citation	Summary	Comment
Practice and Procedure, Administrative Code of Texas	13 TAC Part 2, Chapter 26	Regulations implementing the Antiquities Code of Texas. Describes criteria for evaluating archaeological sites and permit requirements for archaeological excavation.	This requirement is only applicable if an archaeological site is found.
State of Texas Threatened and Endangered Species Regulations	31 TAC 65.171 - 65.176	No person may take, possess, propagate, transport, export, sell or offer for sale, or ship any species of fish or wildlife listed as threatened or endangered.	No readily available information suggests endangered or threatened species in the project area. NMFS includes endangered sea turtles in Trust resources impacted by contaminated surface water and sediments likely transported from the site. The presence or absence of state T&E species will be documented for the site as part of the FS.
TCCC Policies for Development in Critical Areas	31 TAC §501.23	Dredging in critical areas is prohibited if activities have adverse effects or degradation on shellfish and/or jeopardize the continued existence of endangered species or results in an adverse effect on a coastal natural resource area (CNRA)[5]; prohibit the location of facilities in coastal natural resource areas unless adverse effects are prevented and/or no practicable alternative. Actions should not be conducted during spawning or nesting seasons or during seasonal migration periods. Specifies compensatory mitigation.	The FS will evaluate the potential effects of remedial alternatives on Coastal Natural Resource Area (CNRAs), which includes coastal wetlands (Railroad Commission of Texas n.d.).
Texas Coastal Management Plan Consistency	31 TAC, §506.12	Specifies Federal actions within the CMP boundary that may adversely affect CNRAs; specifically selection of remedial actions.	Patrick Bayou lies within the Coastal Zone Boundary (GLO TCMP). The FS will evaluate whether remedial alternatives may affect (adversely or not) the coastal zone and will provide a technical basis for the lead agency to determine whether the activity will be consistent with the State's CZMP (USEPA 1989).
Texas State Code – obstructions to navigation	Natural Resources Code § 51.302 Prohibition and Penalty	Prohibits construction or maintenance of any structure or facility on land owned by the State without an easement, lease, permit, or other instrument from the State.	The FS will evaluate whether the remedial alternatives include construction on State-owned land.
Noise Regulations	Texas Penal Code Chapter 42, Section 42.01	The Texas Penal Code regulates any noise that exceeds 85 decibels after the noise is identified as a public nuisance.	Noise abatement may be required if actions are identified as a public nuisance. Due to the isolation of the site, its location adjacent to a freeway with high volumes of traffic during normal working hours, and the industrial nature of the nearest properties, noise from construction activity associated with a potential remedial action is unlikely to constitute a public nuisance. Noise associated with truck traffic to and from the site should be considered.
Local			
Harris County Floodplain Management Permit[6]	Regulations of Harris County, Texas for Flood Plain Management	All development occurring within the floodplain of unincorporated Harris County requires a permit from Harris County; provide land use controls necessary to qualify unincorporated areas of Harris County for flood insurance under requirements of the National Flood Insurance Act of 1968, as amended, to protect human life and health (Harris County 2007).	Floodplain management is addressed under the Federal requirements for floodplains.
Port Authority of Houston Marine Construction Permit	Section 1, Chapter 97, Acts of the 40th Legislature	Development on or access to lands and property owned by the Port of Houston Authority requires a license or permit.	May be applicable for off-site actions if a remedial alternative requires short- or long-term use of Port of Houston Authority property.
City of Deer Park Floodplain Development	City of Deer Park Code of Ordinances Part II Chapter 46	All development or earth-disturbing activity within the floodplain of Deer Park requires a permit.	Floodplain management is addressed under the Federal requirements for floodplains.

[5] A CNRA is a coastal wetland, oyster reef, hard substrate reef, submerged aquatic vegetation, tidal sand, or mud flat.
[6] Harris County authorization is based upon Texas Local Government Code Section 240.901, as amended; Texas Transportation Code Sections 251.001 - 251.059 and Sections 254.001 - 254.019, as amended; the Harris County Road Law, as amended; and the Flood Control and Insurance Act, Subchapter I of Chapter 16 of the Texas Water Code, as amended.

Table 8-1
Potential ARAR Screening for the Patrick Bayou Superfund Site, Remedial Alternatives Technology Screening

Potential ARARs	Citation	Summary	Comment
City of Deer Park Stormwater Management	City of Deer Park Code of Ordinances Part II Chapter 106	No landowner shall conduct land disturbing activities, including building or grading without a permit.	May be applicable if the remedial alternative including use of uplands for material management or rehandling activities. Permits are not required for on-site CERCLA actions, but the action would be performed in conformance with substantive technical requirements.

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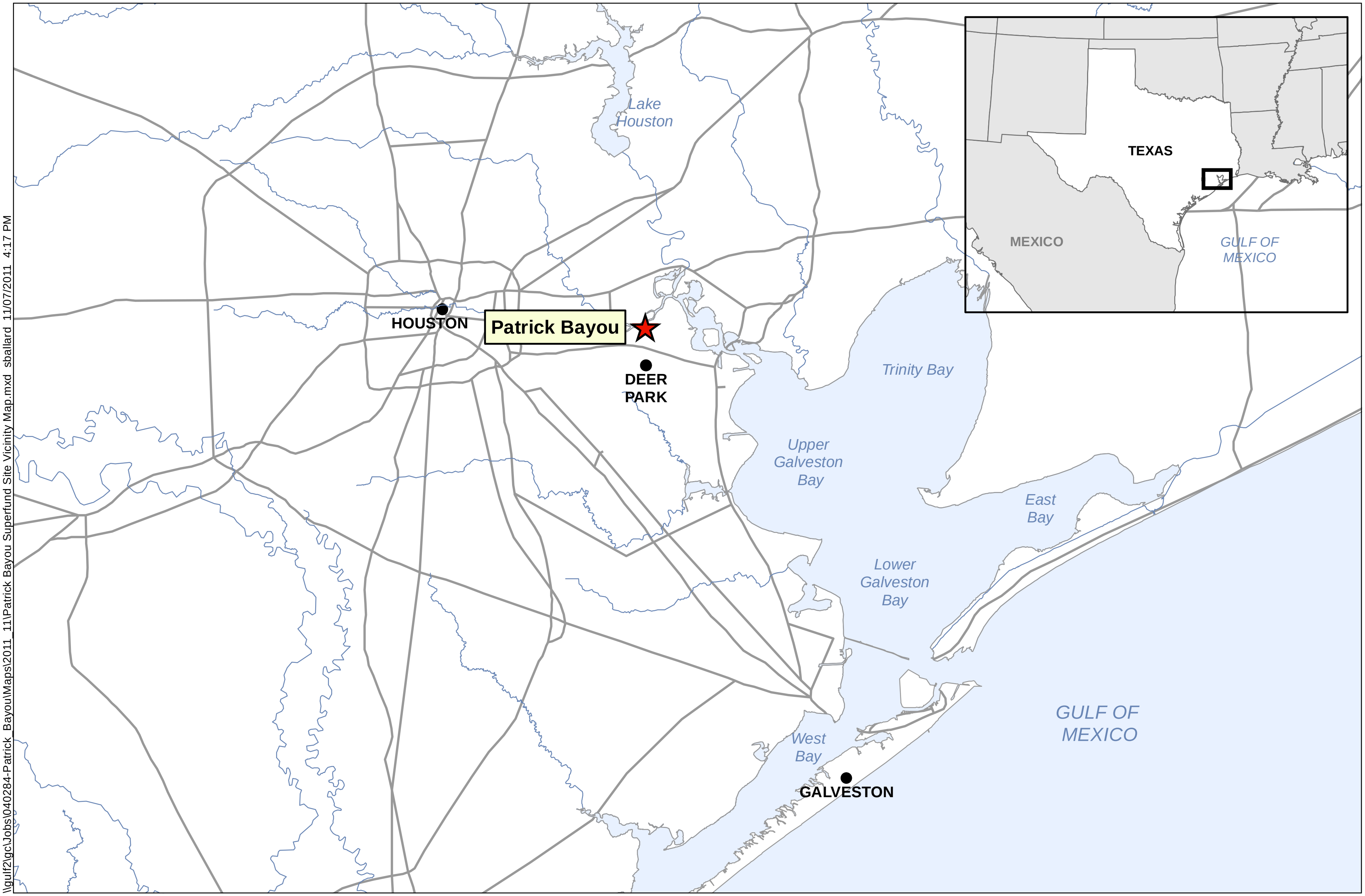
FIGURES



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ANCHOR QEA

Figure 1-1
Patrick Bayou Superfund Site Vicinity Map
Patrick Bayou Remedial Investigation Report
Patrick Bayou Superfund Site Remedial Investigation, Deer Park, Texas

ANCHOR QEA

NOTES:
Stations are placed in 500-foot intervals. Station numbers indicate length along channel in hundreds of feet.
Aerial imagery: Microsoft Bing Maps, copyright 2010 (accessed 5/31/2013.)

Feet
0 500 1,000

Figure 1-2
Patrick Bayou Superfund Site Boundaries
Patrick Bayou Remedial Investigation Report
Patrick Bayou Superfund Site Remedial Investigation, Deer Park, Texas

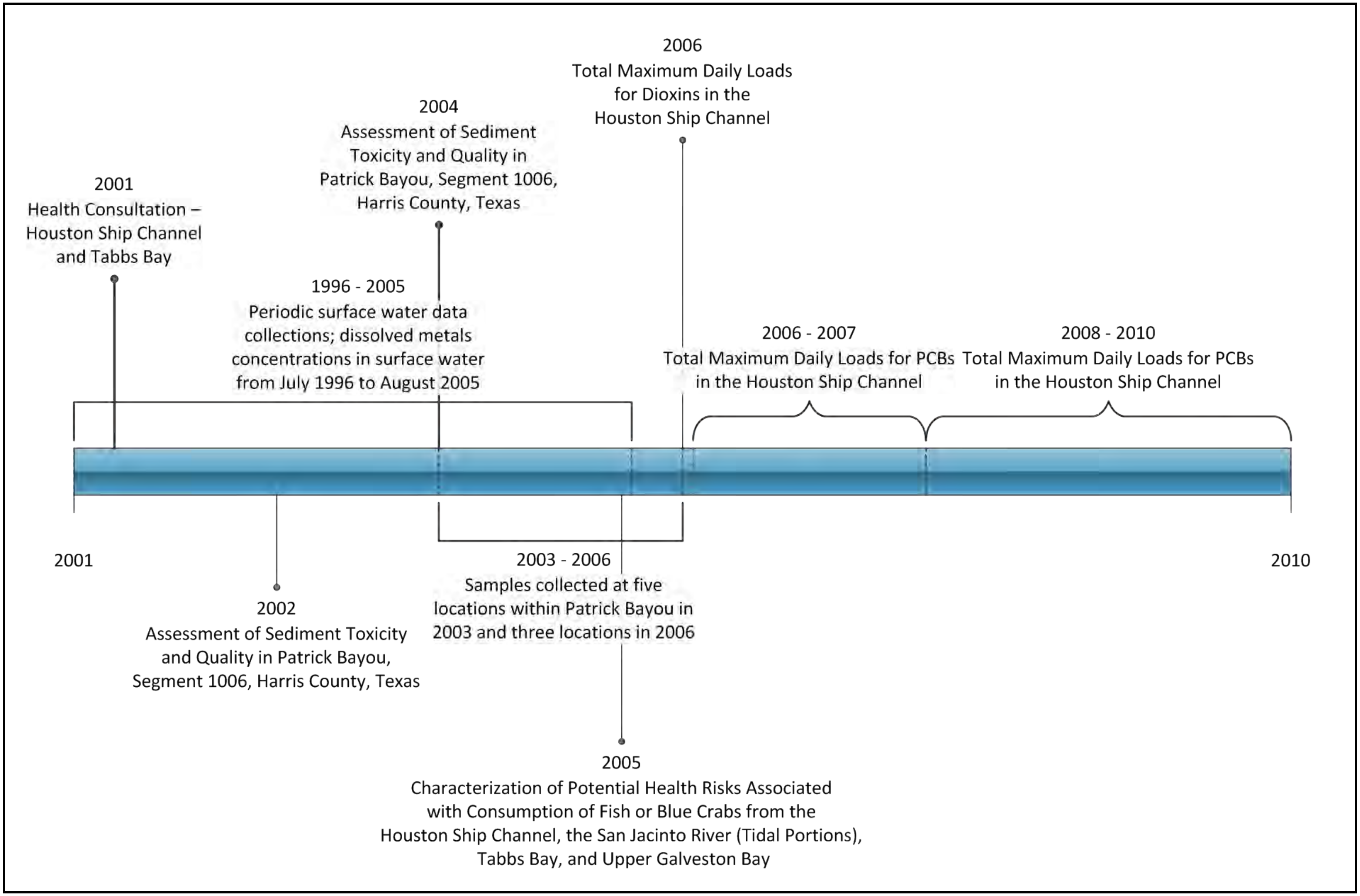


Figure 2-1
Timeline of Historical and Third Party Reports and Investigations
Patrick Bayou Remedial Investigation Report
Patrick Bayou Superfund Site Remedial Investigation, Deer Park, Texas

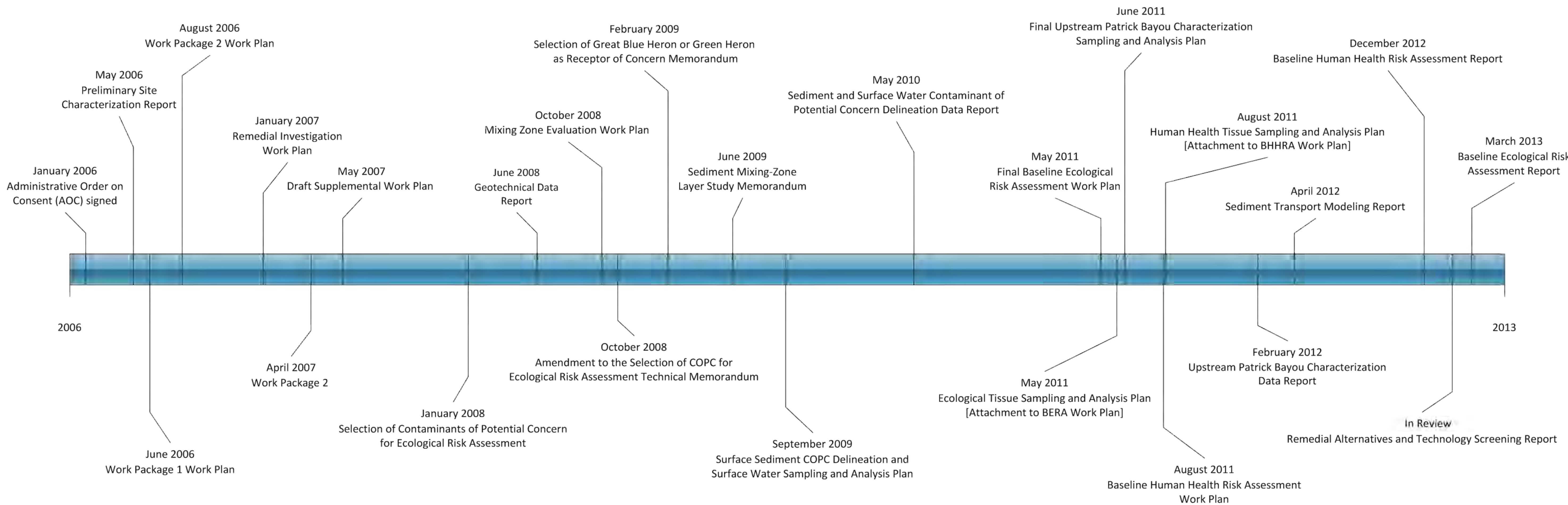


Figure 2-2
Timeline of RI/FS Reports and Investigations
Patrick Bayou Remedial Investigation Report
Patrick Bayou Superfund Site Remedial Investigation, Deer Park, Texas

ANCHOR QEA

NOTES:
Station numbers from Patrick Bayou PSCR indicate length along channel in hundreds of feet.
Aerial imagery: Microsoft Bing Maps, copyright 2010 (accessed 9/6/2013).

Feet
0 500 1,000

Figure 2-3
Continuous Surface Water Monitoring Data Collection Platform Locations
Patrick Bayou Remedial Investigation Report
Patrick Bayou Superfund Site Remedial Investigation, Deer Park, Texas

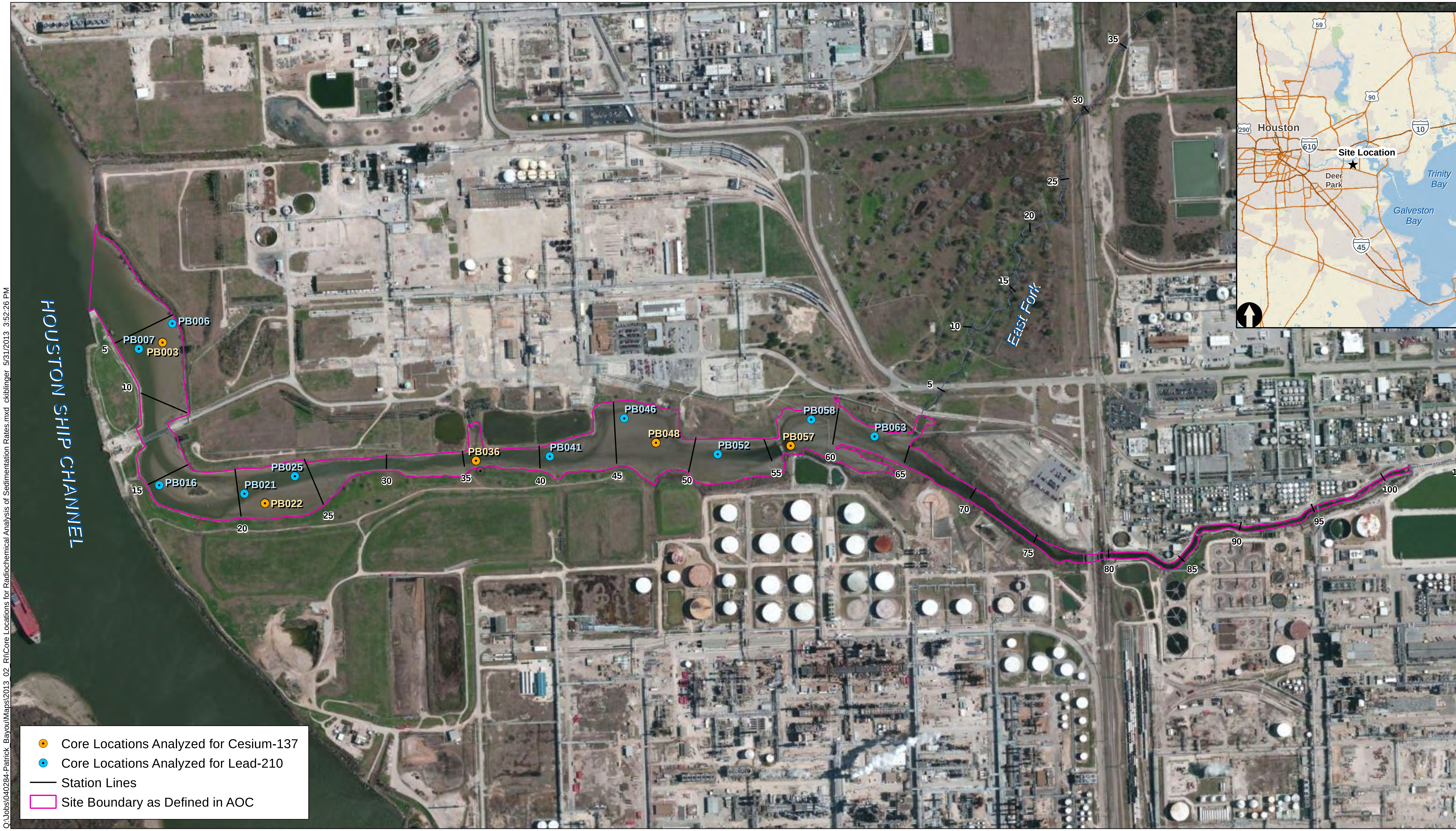
Q:\Jobs\040284-Patrick_Bayou\Maps\2013_02_RI\Continuous Total Suspended Solids Sampling Locations.mxd ckiblinger 6/6/2013 9:44:27 AM

ANCHOR QEA

NOTES:
Station numbers from Patrick Bayou PSCR indicate length along channel in hundreds of feet.
Aerial imagery: Microsoft Bing Maps, copyright 2010 (accessed 6/6/2013).

Feet
0 500 1,000

Figure 2-4
Continuous Total Suspended Solids Sampling Locations
Patrick Bayou Remedial Investigation Report
Patrick Bayou Superfund Site Remedial Investigation, Deer Park, Texas



Q:\Jobs\040284-Patrick_Bayou\Maps\2013_02_RI\Core Locations for Radiochemical Analysis of Sedimentation Rates.mxd ckiblinger 5/31/2013 3:52:26 PM

ANCHOR QEA

NOTES:
Station numbers from Patrick Bayou PSCR indicate length along channel in hundreds of feet.
Aerial imagery: Microsoft Bing Maps, copyright 2010 (accessed 5/31/2013).

Figure 2-5
Core Locations for Radiochemical Analysis of Sedimentation Rates
Patrick Bayou Remedial Investigation Report
Patrick Bayou Superfund Site Remedial Investigation, Deer Park, Texas

ANCHOR QEA

NOTES:
Station numbers from Patrick Bayou PSCR indicate length along channel in hundreds of feet.
Aerial imagery: Microsoft Bing Maps, copyright 2010 (accessed 5/31/2013).

Feet
0 500 1,000

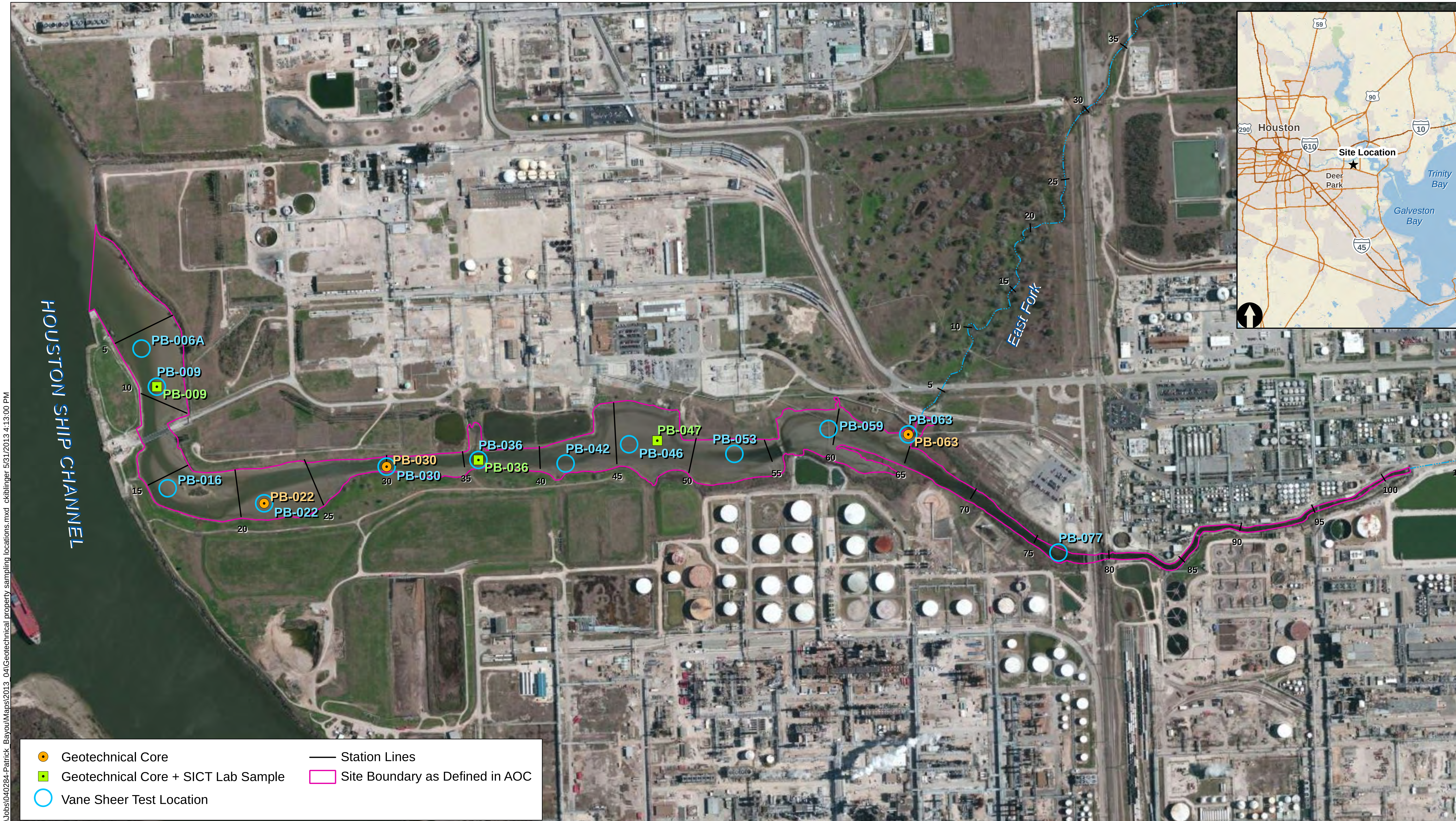
Figure 2-6
Marker Horizon Locations for Evaluation of Sediment Accretion
Patrick Bayou Remedial Investigation Report
Patrick Bayou Superfund Site Remedial Investigation, Deer Park, Texas

ANCHOR QEA

NOTES:
Station numbers from Patrick Bayou PSCR indicate length along channel in hundreds of feet.
Aerial imagery: Microsoft Bing Maps, copyright 2010 (accessed 5/31/2013).

Feet
0 500 1,000

Figure 2-7
Core Locations for Evaluating Sediment Stability and Erodibility
Patrick Bayou Remedial Investigation Report
Patrick Bayou Superfund Site Remedial Investigation, Deer Park, Texas

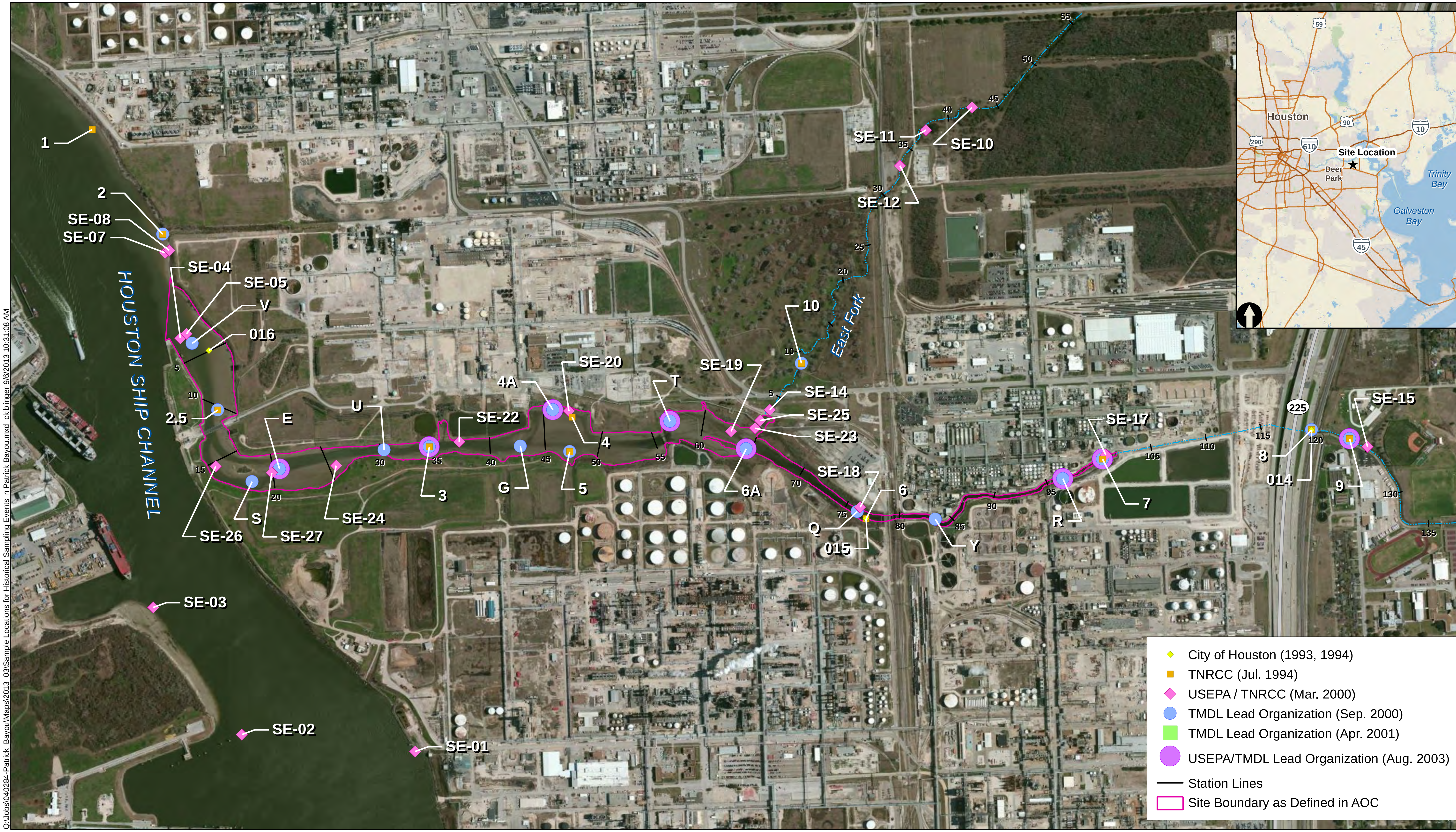


ANCHOR QEA

NOTES:
Stations are placed in 500-foot intervals. Station numbers indicate length along channel in hundreds of feet.
Aerial imagery: Microsoft Bing Maps, copyright 2010 (accessed 5/31/2013.)

Feet
0 500 1,000

Figure 2-8
Geotechnical Property Sampling Locations
Patrick Bayou Remedial Investigation Report
Patrick Bayou Superfund Site Remedial Investigation, Deer Park, Texas



Q:\Jobs\040284-Patrick_Bayou\Maps\2013_03\Sample Locations for Historical Sampling Events in Patrick Bayou.mxd ckiblinger 9/6/2013 10:31:08 AM

ANCHOR QEA

NOTES:
Station numbers from Patrick Bayou PSCR indicate length along channel in hundreds of feet.
Aerial imagery: Microsoft Bing Maps, copyright 2010 (accessed 9/6/2013.)

Feet
0 500 1,000

Figure 2-9
Sample Locations for Historical Sampling Events in Patrick Bayou
Patrick Bayou Remedial Investigation Report
Patrick Bayou Superfund Site Remedial Investigation, Deer Park, Texas

Q:\Jobs\040284-Patrick_Bayou\Maps\2013_02_RI\Core Locations for Vertical Sediment Chemistry Characterization.mxd ckiblinger 5/31/2013 4:29:37 PM

ANCHOR QEA

NOTES:
Station numbers from Patrick Bayou PSCR indicate length along channel in hundreds of feet.
Aerial imagery: Microsoft Bing Maps, copyright 2010 (accessed 5/31/2013).

Feet
0 500 1,000

Figure 2-10
Core Locations for Vertical Sediment Chemistry Characterization
Patrick Bayou Remedial Investigation Report
Patrick Bayou Superfund Site Remedial Investigation, Deer Park, Texas

ANCHOR QEA

NOTES:
Station numbers from Patrick Bayou PSCR indicate length along channel in hundreds of feet.
Aerial imagery: Microsoft Bing Maps, copyright 2010 (accessed 6/3/2013).

Feet
0 500 1,000

Figure 2-11
Surface Sediment Samples Upstream of Site Boundary
Patrick Bayou Remedial Investigation Report
Patrick Bayou Superfund Site Remedial Investigation, Deer Park, Texas

G:\Jobs\040284-Patrick_Bayou\Maps\2013_06\RI Fig 2-12 Lateral SE.mxd sballard 6/3/2013 5:23:57 PM

ANCHOR QEA

NOTES:
Station numbers from Patrick Bayou PSCR indicate length along channel in hundreds of feet.
Aerial imagery: Microsoft Bing Maps, copyright 2010 (accessed 6/3/2013).

Feet
0 500 1,000

Figure 2-12
Sediment Samples Collected for Lateral Characterization of Patrick Bayou
Patrick Bayou Remedial Investigation Report
Patrick Bayou Superfund Site Remedial Investigation, Deer Park, Texas

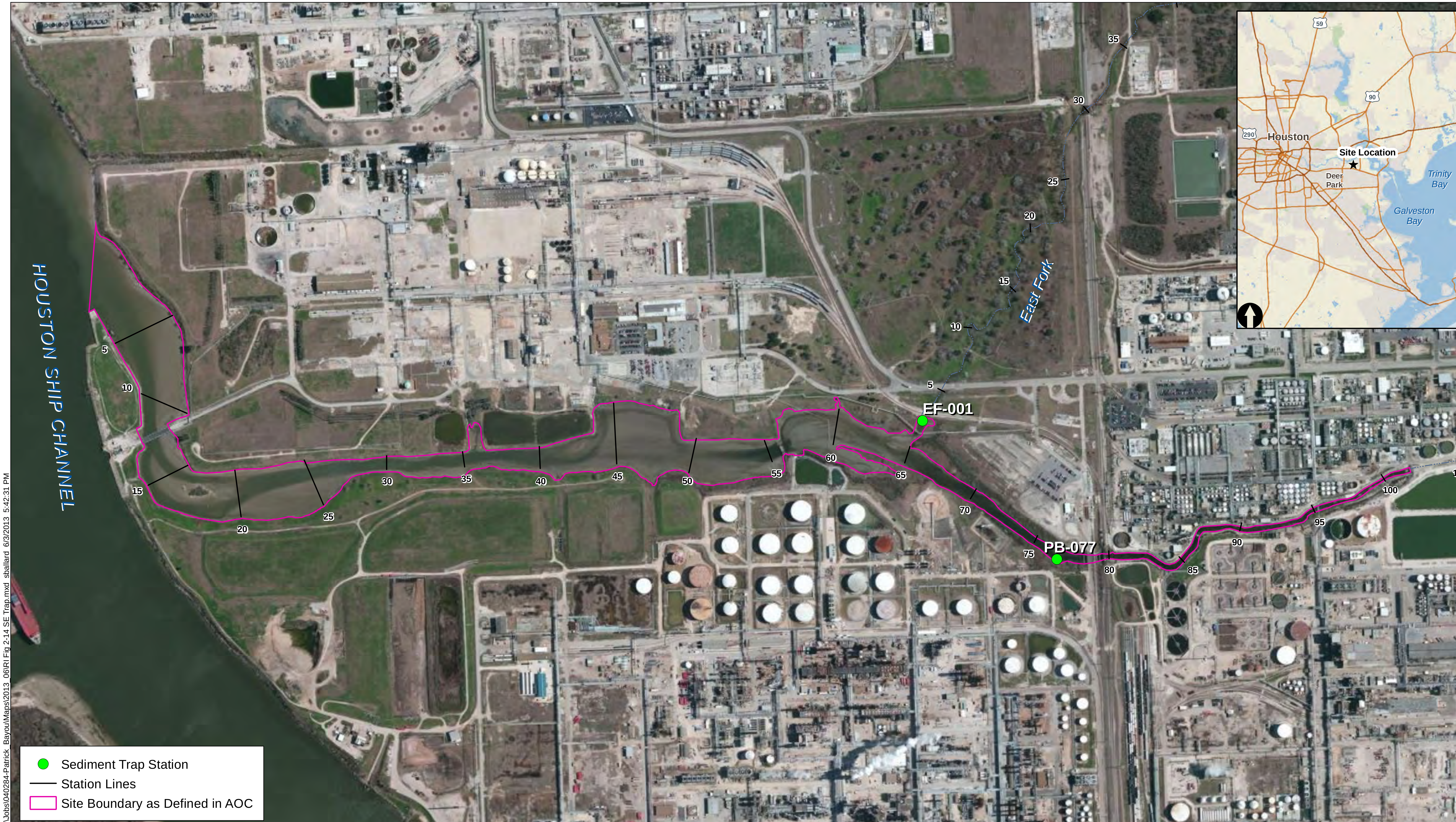
G:\Jobs\040284-Patrick_Bayou\Maps\2013_06\RI Fig 2-13 PW.mxd sballard 6/3/2013 5:29:21 PM

ANCHOR QEA

NOTES:
Station numbers from Patrick Bayou PSCR indicate length along channel in hundreds of feet.
Aerial imagery: Microsoft Bing Maps, copyright 2010 (accessed 6/3/2013).

Feet
0 500 1,000

Figure 2-13
Porewater Sample Locations
Patrick Bayou Remedial Investigation Report
Patrick Bayou Superfund Site Remedial Investigation, Deer Park, Texas

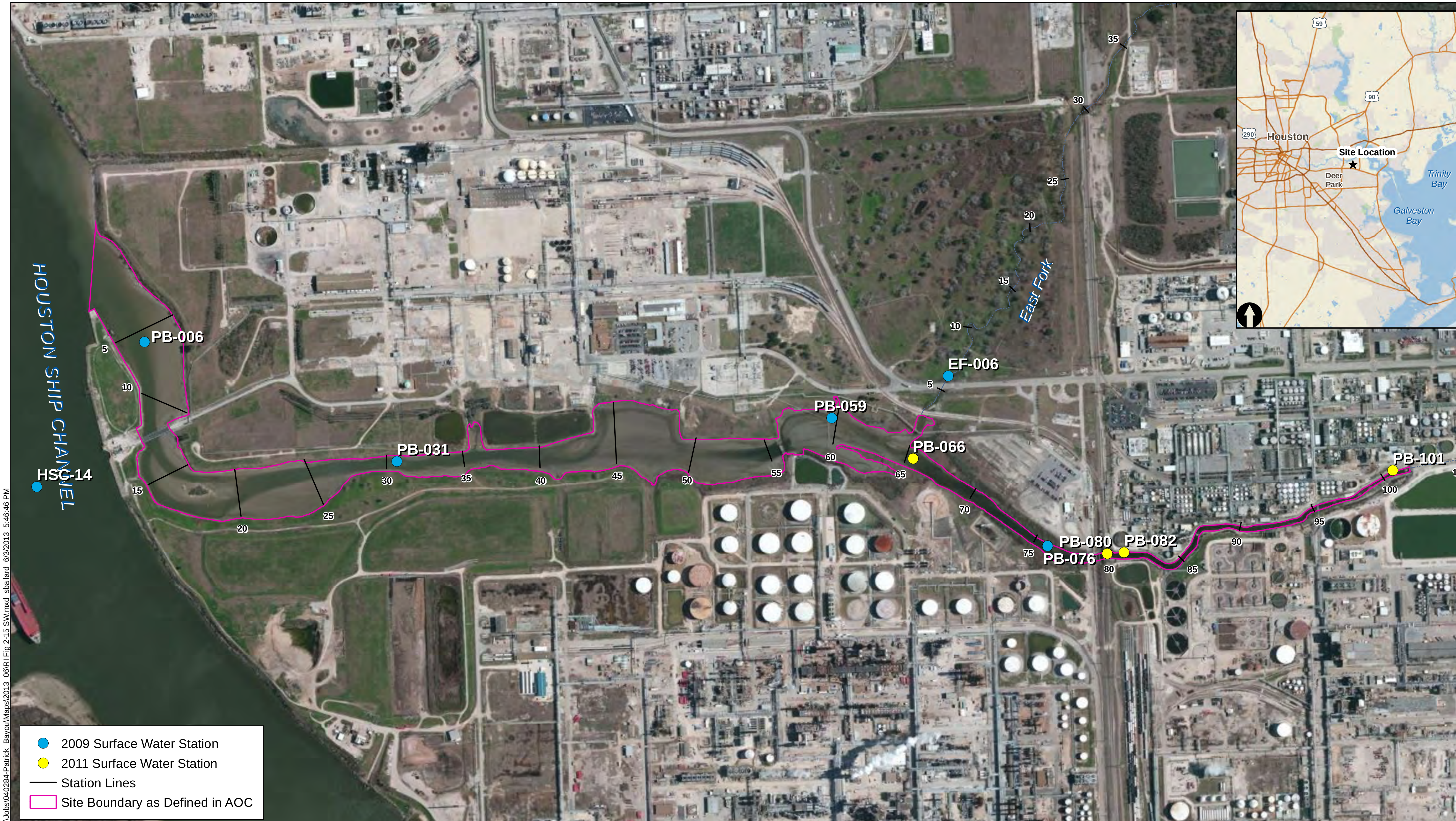


G:\Jobs\040284-Patrick_Bayou\Maps\2013_06\RI Fig 2-14 SE Trap.mxd sballard 6/3/2013 5:42:31 PM

ANCHOR QEA

NOTES:
Station numbers from Patrick Bayou PSCR indicate length along channel in hundreds of feet.
Aerial imagery: Microsoft Bing Maps, copyright 2010 (accessed 6/3/2013).

Figure 2-14
Sediment Trap Locations
Patrick Bayou Remedial Investigation Report
Patrick Bayou Superfund Site Remedial Investigation, Deer Park, Texas



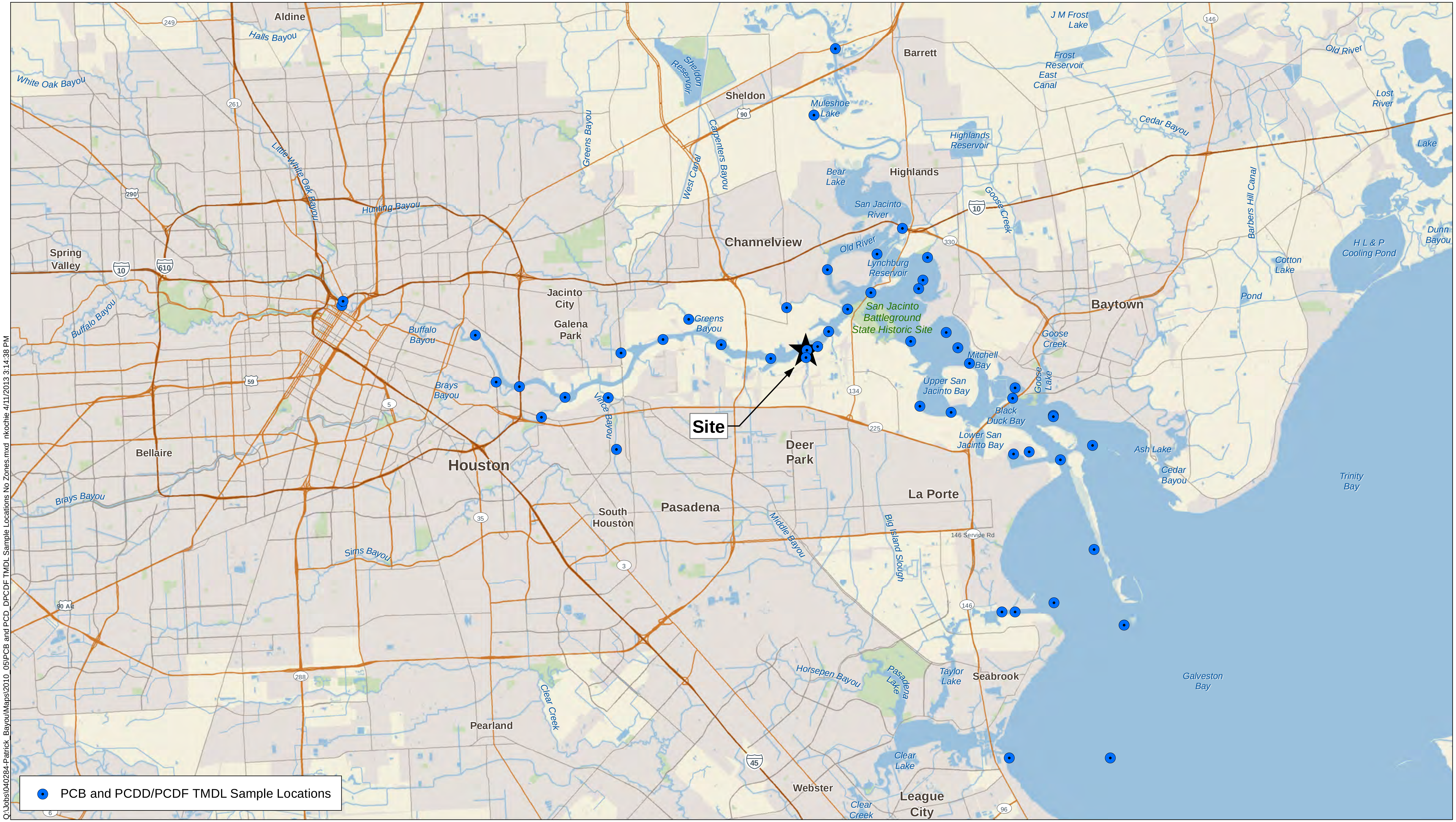
G:\Jobs\040284-Patrick_Bayou\Maps\2013_06\RI Fig 2-15 SW.mxd sballard 6/3/2013 5:46:46 PM

ANCHOR QEA

NOTES:
Station numbers from Patrick Bayou PSCR indicate length along channel in hundreds of feet.
Aerial imagery: Microsoft Bing Maps, copyright 2010 (accessed 6/3/2013).

Feet
0 500 1,000

Figure 2-15
Surface Water Station Locations
Patrick Bayou Remedial Investigation Report
Patrick Bayou Superfund Site Remedial Investigation, Deer Park, Texas



ANCHOR QEA

Figure 2-16
TMDL Tissue Sample Locations
Patrick Bayou Remedial Investigation Report
Patrick Bayou Superfund Site Remedial Investigation, Deer Park, TX

G:\Jobs\040284-Patrick_Bayou\Maps\2013_06\RI Fig 2-17 BERA Inverts.mxd sballard 6/3/2013 5:58:24 PM

ANCHOR QEA

NOTES:
Multiple samples may be associated with some sample locations.
Station numbers from Patrick Bayou PSCR indicate length along channel in hundreds of feet.
Aerial imagery: Microsoft Bing Maps, copyright 2010 (accessed 6/3/2013).

Figure 2-17
BERA Dataset Invertebrate Sample Locations
Patrick Bayou Remedial Investigation Report
Patrick Bayou Superfund Site Remedial Investigation, Deer Park, Texas

ANCHOR QEA

NOTES:
Multiple samples may be associated with some sample locations.
Station numbers from Patrick Bayou PSCR indicate length along channel in hundreds of feet.
Aerial imagery: Microsoft Bing Maps, copyright 2010 (accessed 6/3/2013).

Feet
0 500 1,000

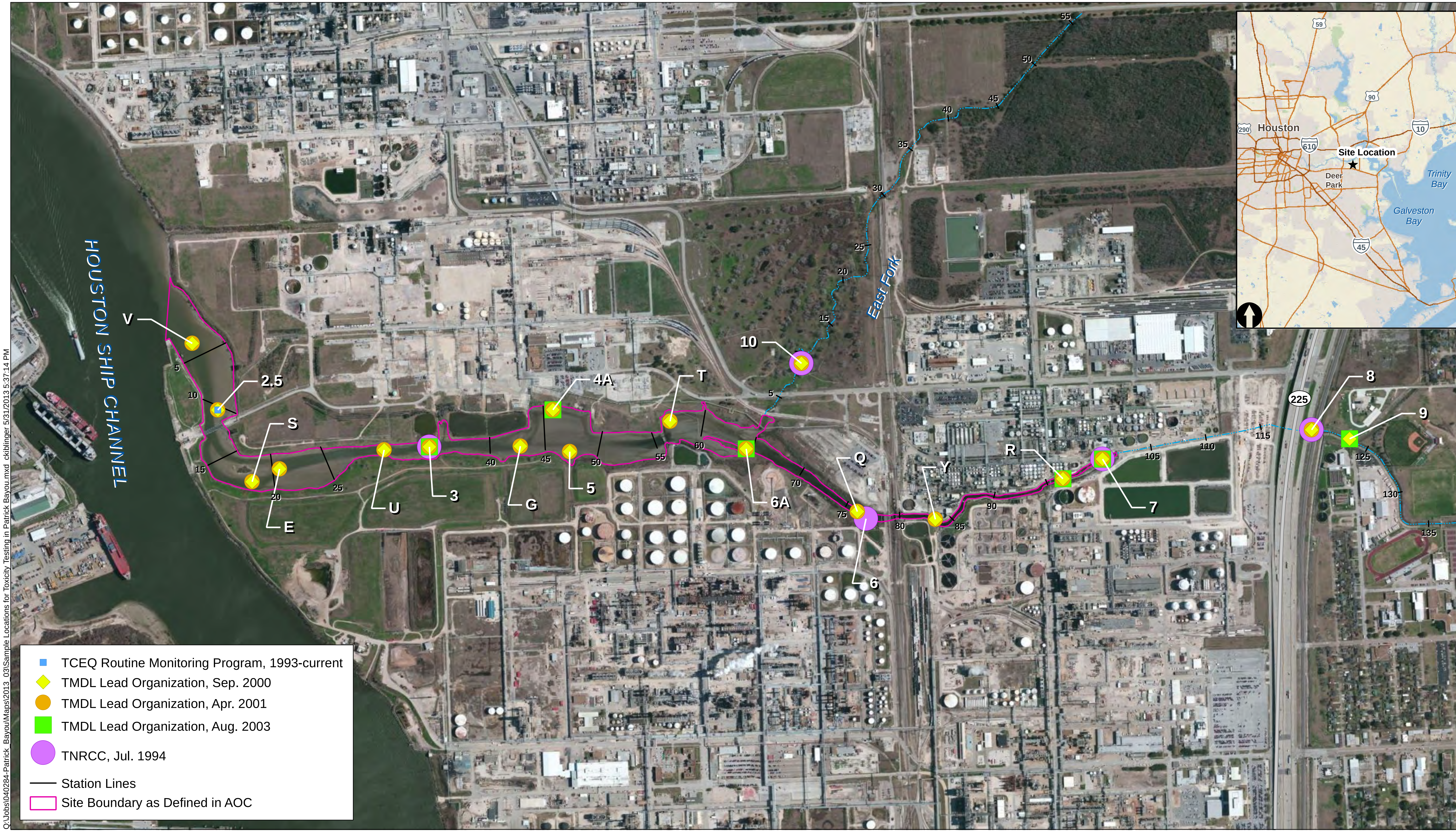
Figure 2-18
BERA Fish Sample Locations
Patrick Bayou Remedial Investigation Report
Patrick Bayou Superfund Site Remedial Investigation, Deer Park, Texas

G:\Jobs\040284-Patrick_Bayou\Maps\2013_06\RI Fig 2-19 BHHRA.mxd sballard 6/3/2013 6:01:34 PM

ANCHOR QEA

NOTES:
Multiple samples may be associated with some sample locations.
Station numbers from Patrick Bayou PSCR indicate length along channel in hundreds of feet.
Aerial imagery: Microsoft Bing Maps, copyright 2010 (accessed 6/3/2013).

Figure 2-19
BHHRA Fish and Shellfish Sample Locations
Patrick Bayou Remedial Investigation Report
Patrick Bayou Superfund Site Remedial Investigation, Deer Park, Texas



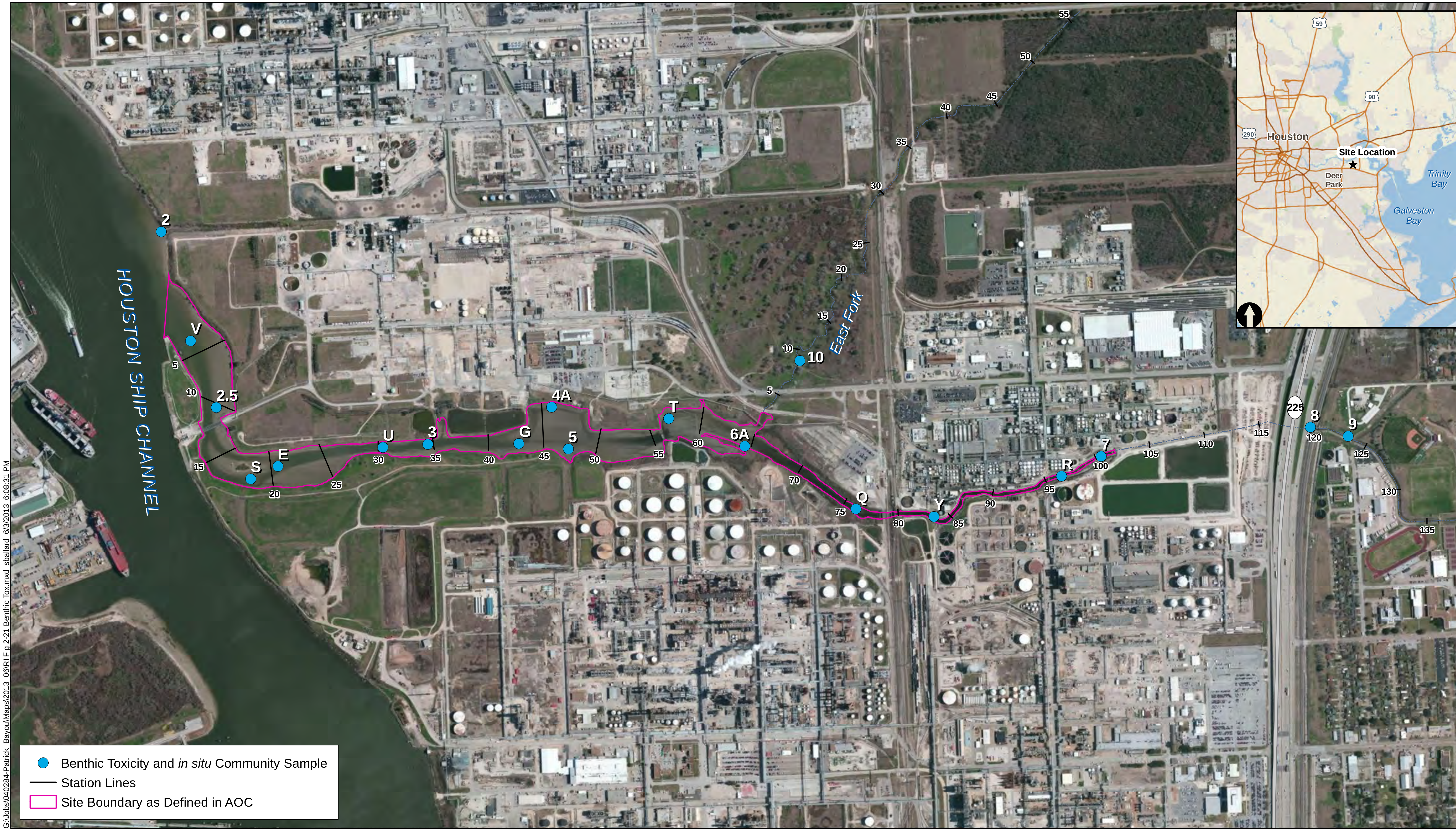
Q:\Jobs\040284-Patrick_Bayou\Maps\2013_03\Sample Locations for Toxicity Testing in Patrick Bayou.mxd ckiblinger 5/31/2013 5:37:14 PM

ANCHOR QEA

NOTES:
Station numbers from Patrick Bayou PSCR indicate length along channel in hundreds of feet.
Aerial imagery: Microsoft Bing Maps, copyright 2010 (accessed 5/31/2013.)

Feet
0 500 1,000

Figure 2-20
Sample Locations for Toxicity Testing in Patrick Bayou
Patrick Bayou Remedial Investigation Report
Patrick Bayou Superfund Site Remedial Investigation, Deer Park, Texas



G:\Jobs\040284-Patrick_Bayou\Maps\2013_06\RI Fig 2-21 Benthic Tox.mxd sballard 6/3/2013 6:08:31 PM

ANCHOR QEA

NOTES:
Station numbers from Patrick Bayou PSCR indicate length along channel in hundreds of feet.
Aerial imagery: Microsoft Bing Maps, copyright 2010 (accessed 6/3/2013).

Feet
0 500 1,000

Figure 2-21
BERA Dataset Benthic Toxicity and *in situ* Community Sample Locations
Patrick Bayou Remedial Investigation Report
Patrick Bayou Superfund Site Remedial Investigation, Deer Park, Texas

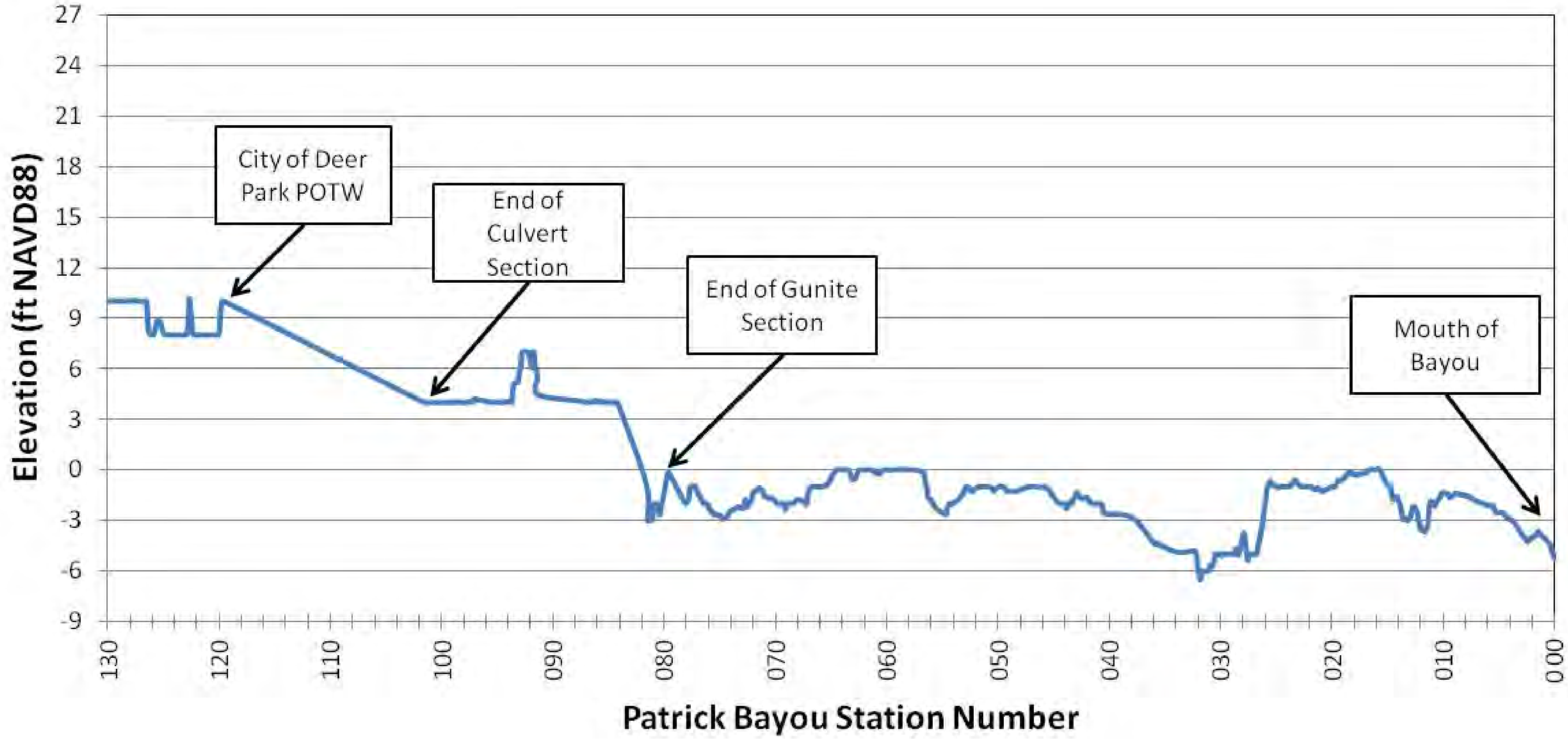
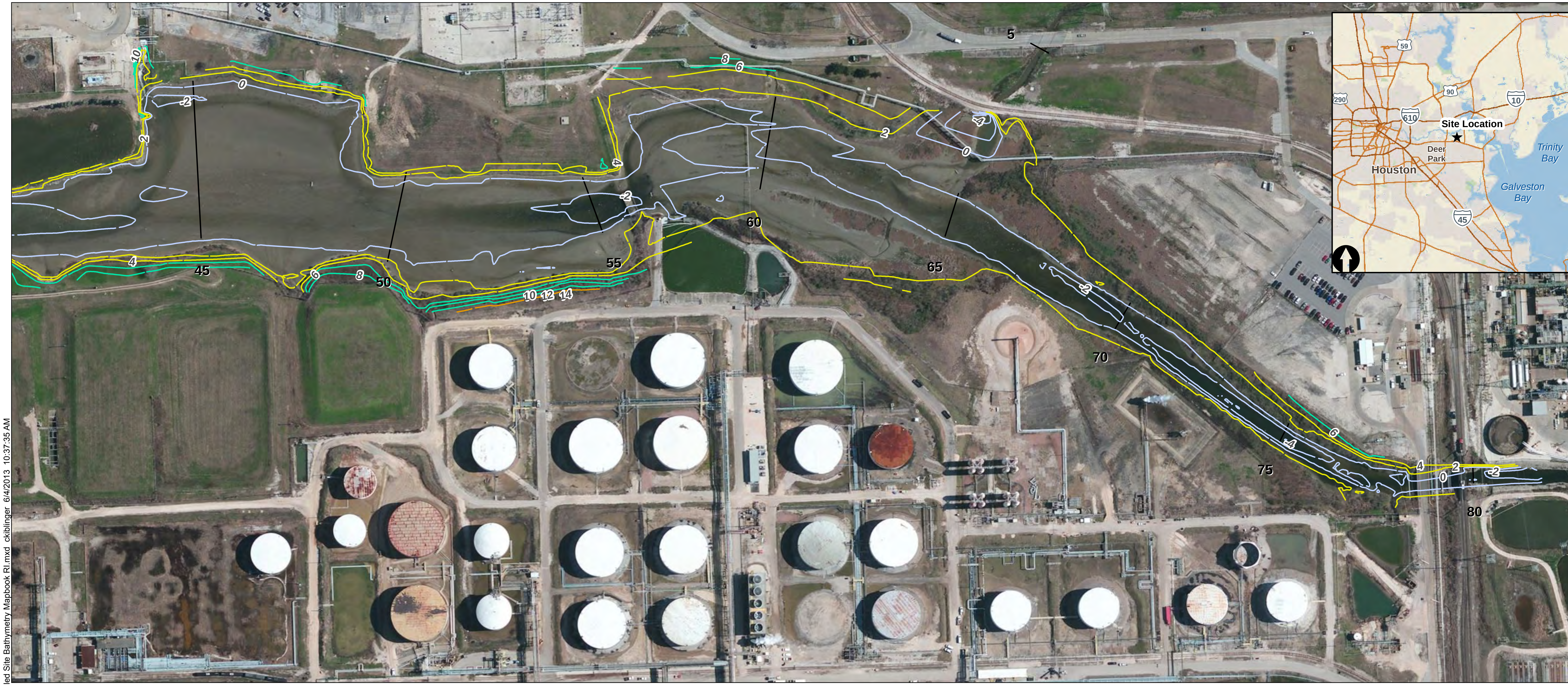


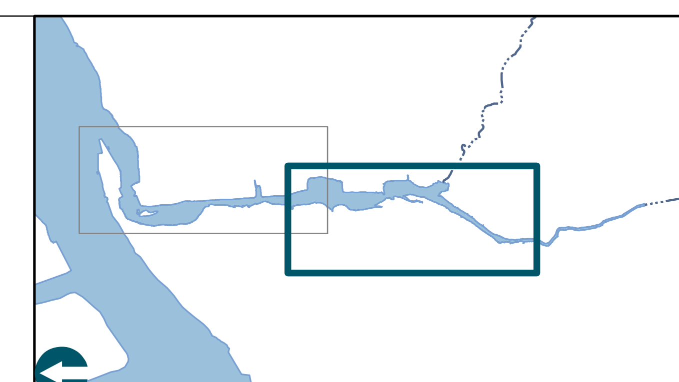
Figure 3-1
Profile of Bed Elevation in Patrick Bayou
Patrick Bayou Remedial Investigation Report
Patrick Bayou Superfund Site Remedial Investigation, Deer Park, Texas



2-foot Contours
≤ -5
-4 - 0
1 - 5
6 - 10
> 10
Station Lines

NOTES:
1. Bathymetry: GBA Survey, May/June 2005.
2. Contour intervals are in 2-foot intervals referenced to the NAVD88 vertical datum.
3. Station numbers from Patrick Bayou PSCR indicate length along channel in hundreds of feet.
4. Aerial imagery: Microsoft Bing Maps, copyright 2010 (accessed 6/4/2013).

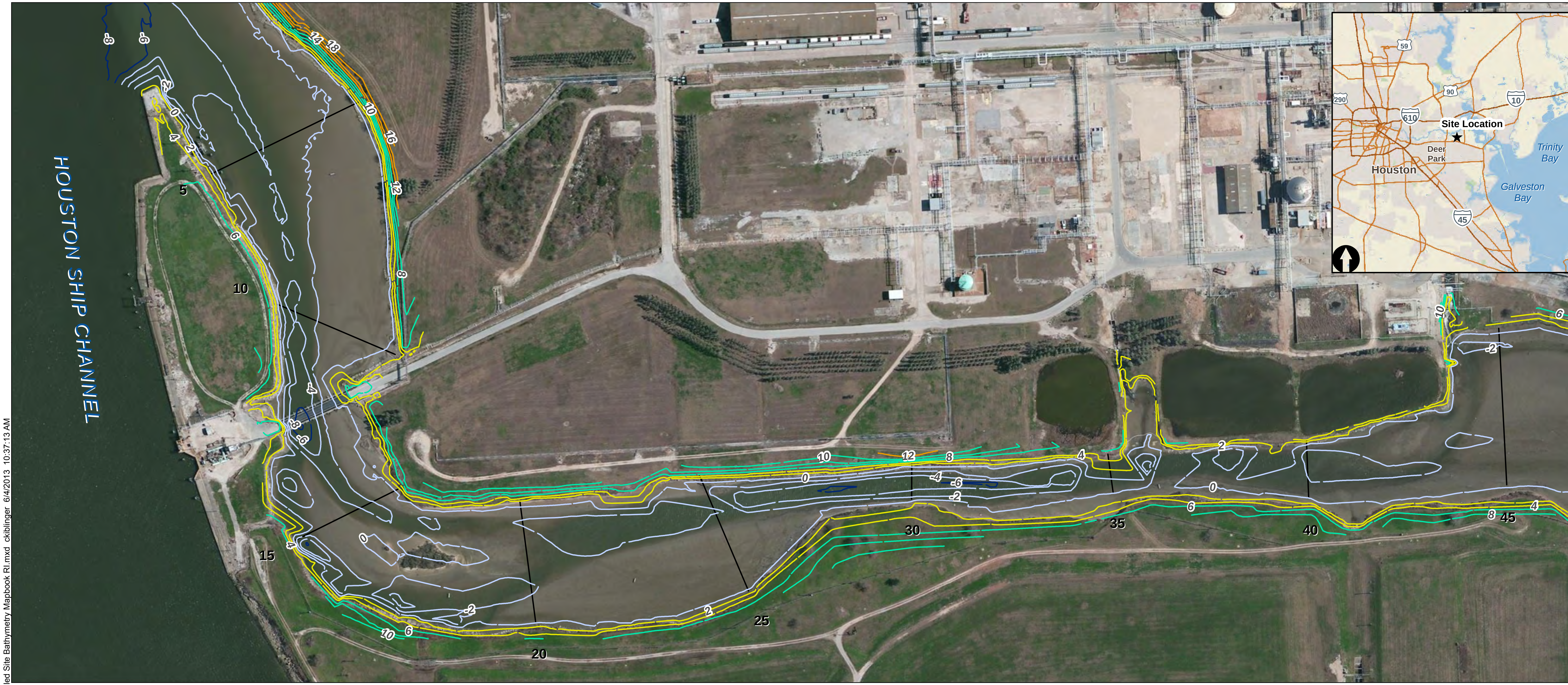
Feet
0 125 250 375 500



Q:\Jobs\040284-Patrick_Bayou\Maps\2013_05_RI\Detailed Site Bathymetry Mapbook RI.mxd ckiblinger 6/4/2013 10:37:35 AM

ANCHOR QEA

Figure 3-2A
Detailed Site Bathymetry
Patrick Bayou Remedial Investigation Report
Patrick Bayou Superfund Site Remedial Investigation, Deer Park, Texas

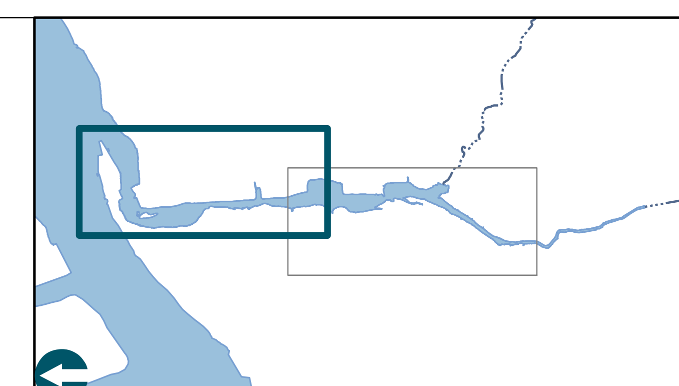


2-foot Contours
- ≤ -5
- -4 - 0
- 1 - 5
- 6 - 10
- > 10

Station Lines

NOTES:
1. Bathymetry: GBA Survey, May/June 2005.
2. Contour intervals are in 2-foot intervals referenced to the NAVD88 vertical datum.
3. Station numbers from Patrick Bayou PSCR indicate length along channel in hundreds of feet.
4. Aerial imagery: Microsoft Bing Maps, copyright 2010 (accessed 6/4/2013).

Feet
0 125 250 375 500



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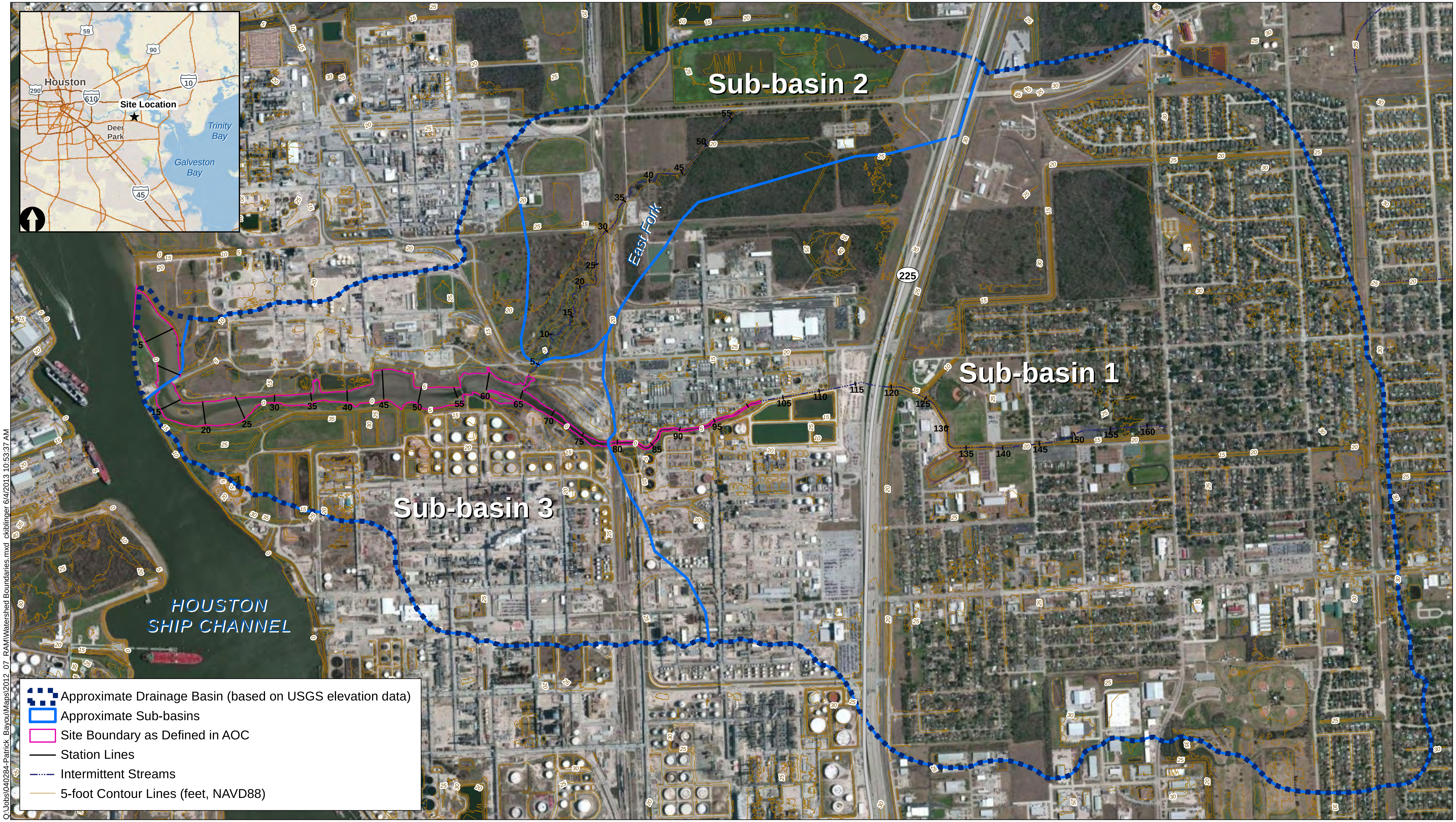
ANCHOR QEA

Figure 3-2B
Detailed Site Bathymetry
Patrick Bayou Remedial Investigation Report
Patrick Bayou Superfund Site Remedial Investigation, Deer Park, Texas

Q:\Jobs\040284-Patrick_Bayou\Maps\2012_07_RAM\Watershed Boundaries.mxd ckiblinger 6/4/2013 10:53:37 AM

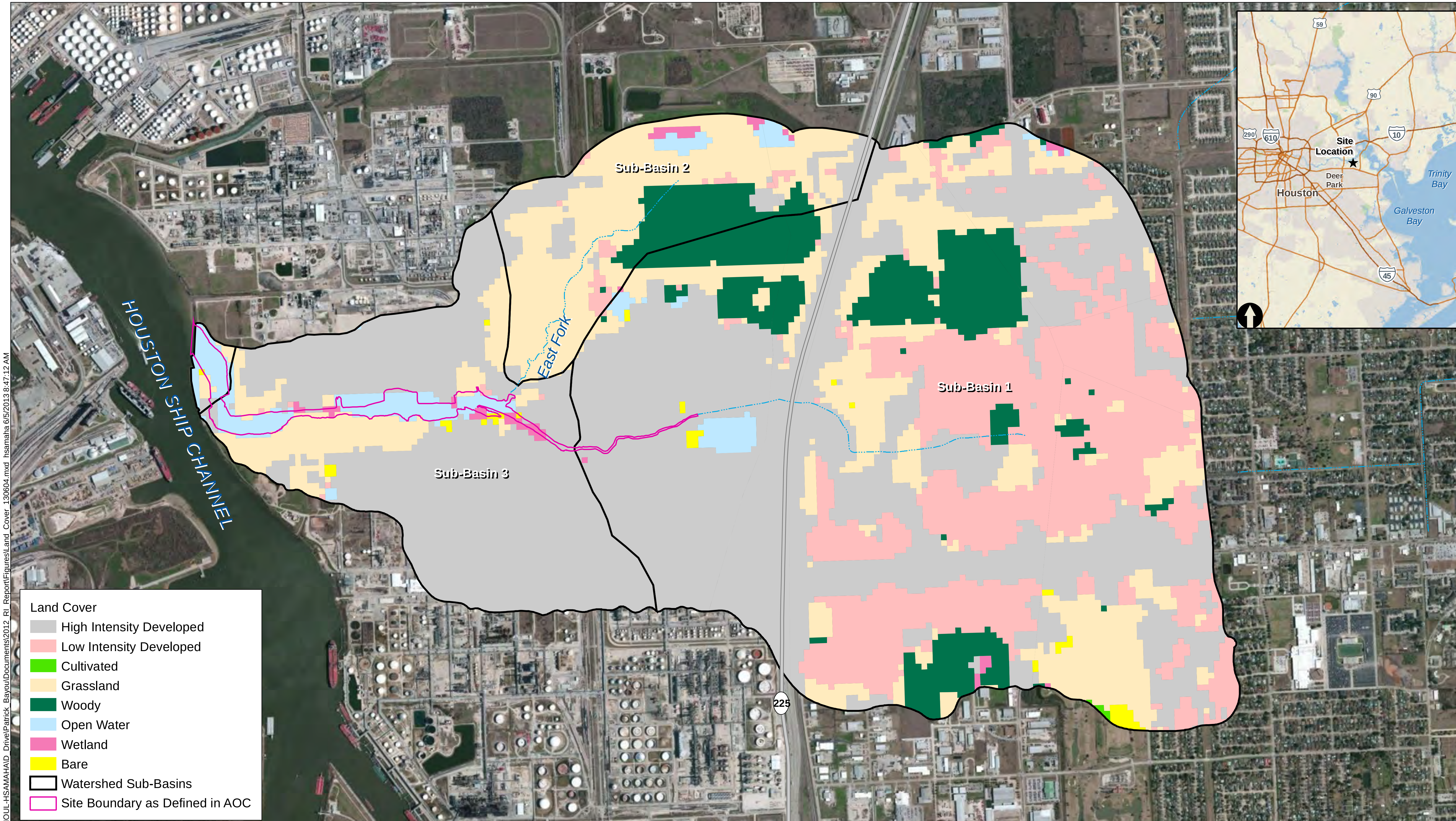


ANCHOR QEA

NOTES:
1. Elevation contours: Houston-Galveston Area Council, 2008 (feet, NAVD88).
2. Note that sub-basin boundaries were determined using a different elevation contour set from that shown on this figure.
3. Stations are placed in 500-foot intervals. Station numbers indicate length along channel in hundreds of feet.
4. Aerial imagery: Microsoft Bing Maps, copyright 2010 (accessed 6/4/2013).

Feet
0 1,250 2,500

Figure 3-3
Watershed and Sub-basin Boundaries
Patrick Bayou Remedial Investigation Report
Patrick Bayou Superfund Site Remedial Investigation, Deer Park, Texas

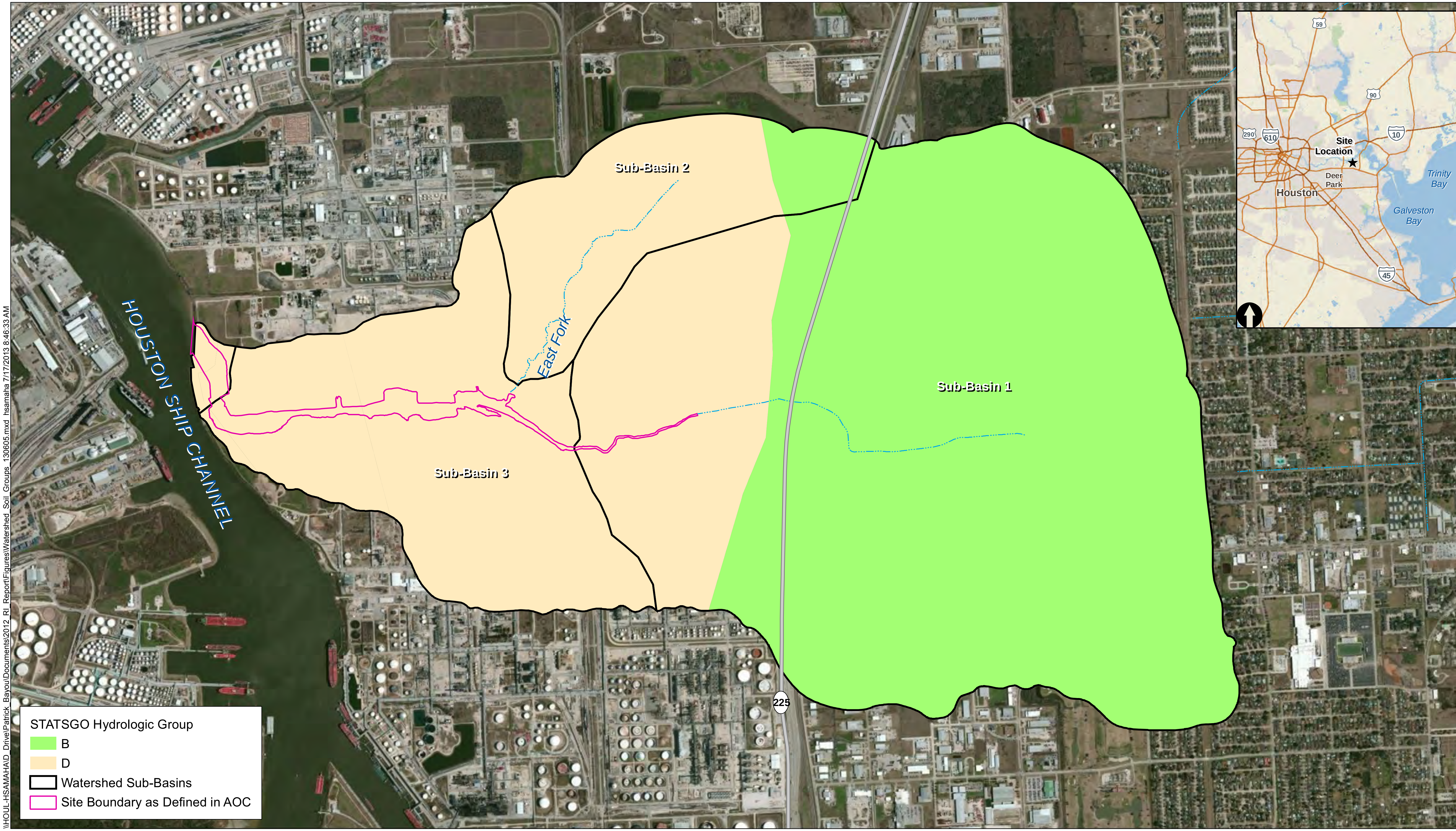


ANCHOR QEA

NOTES:
Aerial imagery: Microsoft Bing Maps, copyright 2010 (accessed 6/5/2013.)

Feet
0 1,000 2,000

Figure 3-4
Surrounding Watershed Land Cover Types
Patrick Bayou Remedial Investigation Report
Patrick Bayou Superfund Site Remedial Investigation, Deer Park, Texas

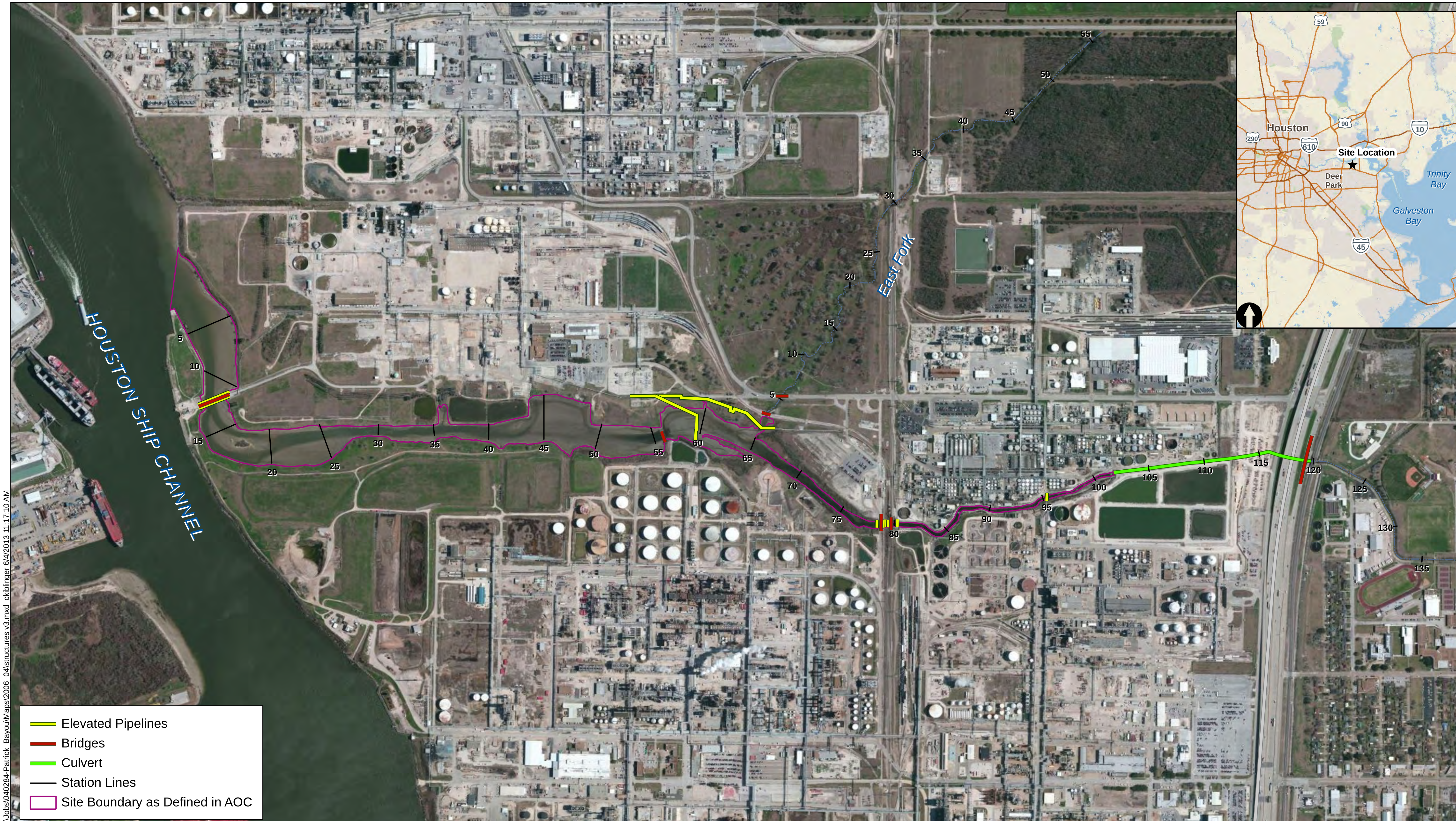


ANCHOR QEA

NOTES:
STATSGO Hydrologic Group Definitions:
B – Between 10 - 20% clay and 50 - 90% sand with loamy sand or sandy loam texture.
D – Greater than 40% clay and less than 50% sand with clayey texture.
Aerial imagery: Microsoft Bing Maps, copyright 2010 (accessed 7/17/2013.)

Feet
0 1,000 2,000

Figure 3-5
Hydrologic Soil Groups for Watershed Sub-Basins
Patrick Bayou Remedial Investigation Report
Patrick Bayou Superfund Site Remedial Investigation, Deer Park, Texas



ANCHOR QEA

NOTES:
1. Bridges and pipelines from GBA Survey, May/June 2005.
2. Stations are placed in 500-foot intervals. Station numbers indicate length along channel in hundreds of feet.
3. Aerial imagery: Microsoft Bing Maps, copyright 2010 (accessed 6/4/2013.)

Feet
0 500 1,000

Figure 3-6
Site Map Showing Structures
Patrick Bayou Remedial Investigation Report
Patrick Bayou Superfund Site Remedial Investigation, Deer Park, Texas

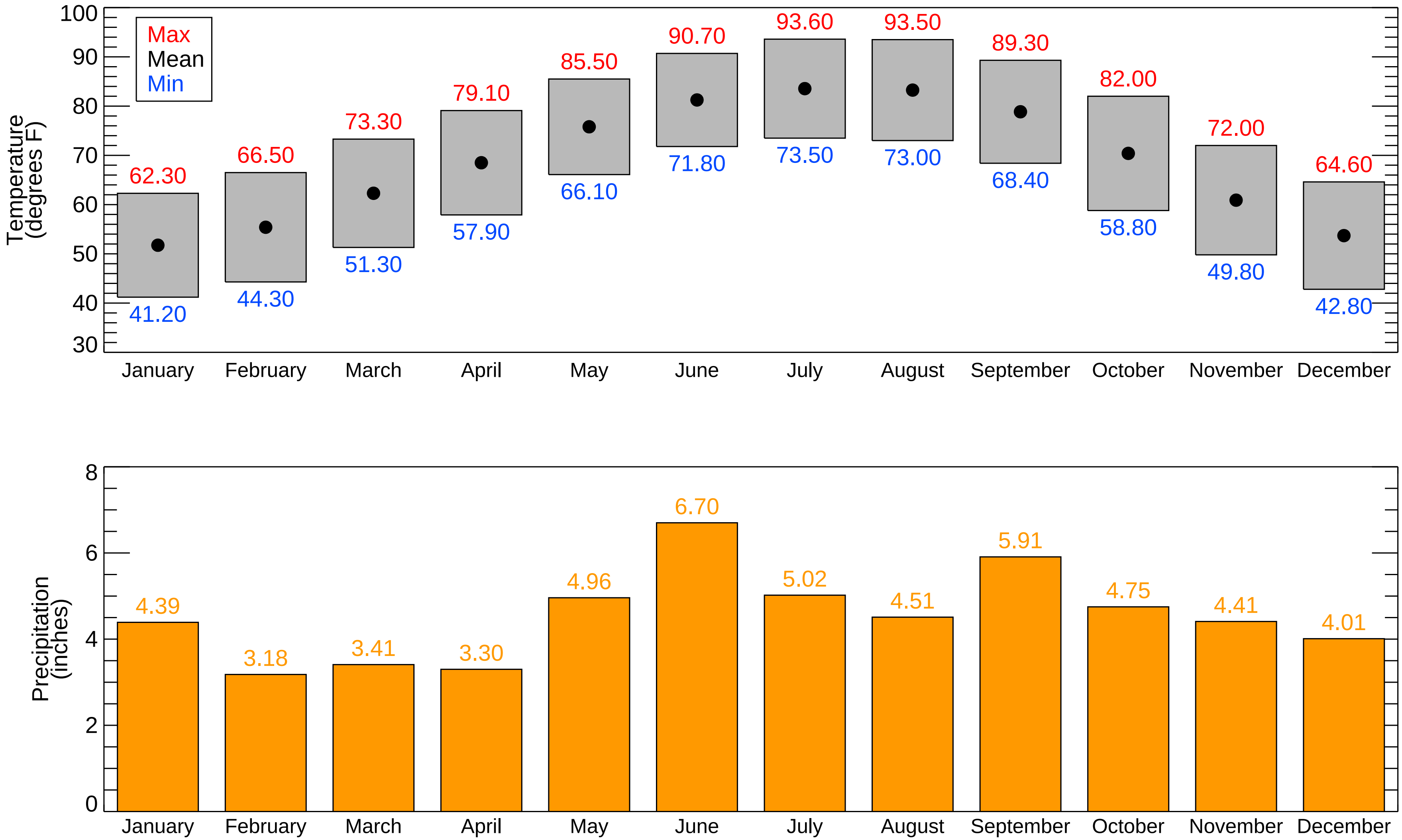


Figure 3-7

Average Seasonal Temperature and Precipitation for the Deer Park Area
Patrick Bayou Remedial Investigation Report
Patrick Bayou Superfund Site Remedial Investigation, Deer Park, Texas

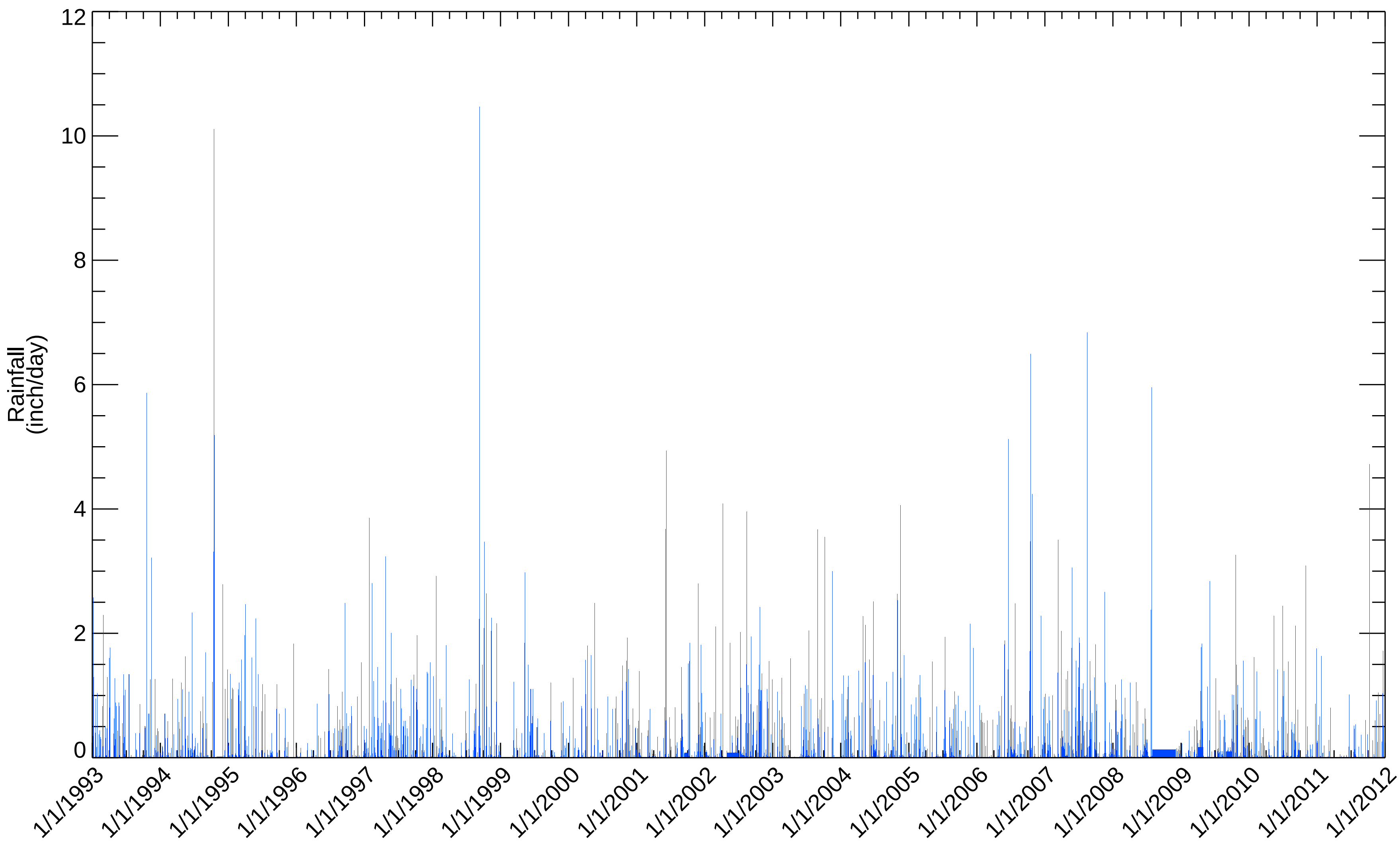
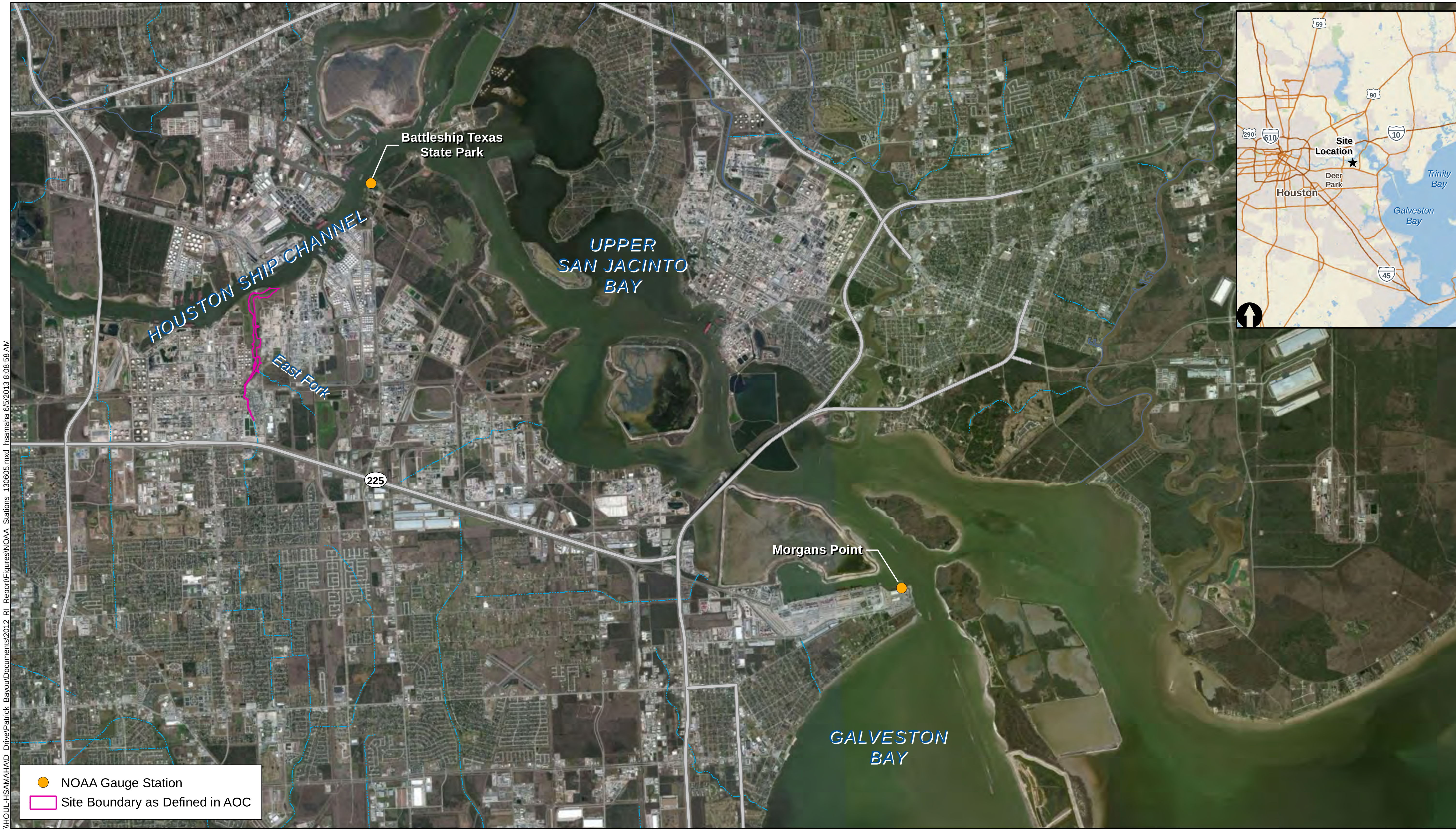


Figure 3-8

Daily Rainfall Totals for the Deer Park Area, 1993-2011

Patrick Bayou Remedial Investigation Report

Patrick Bayou Superfund Site Remedial Investigation, Deer Park, Texas



ANCHOR QEA

NOTES:
Aerial imagery: Microsoft Bing Maps, copyright 2010 (accessed 6/5/2013.)

Feet
0 5,000 10,000

Figure 3-9
Location of NOAA Tidal Gauge Stations at
Battleship Texas State Park and Morgans Point
Patrick Bayou Remedial Investigation Report
Patrick Bayou Superfund Site Remedial Investigation, Deer Park, Texas

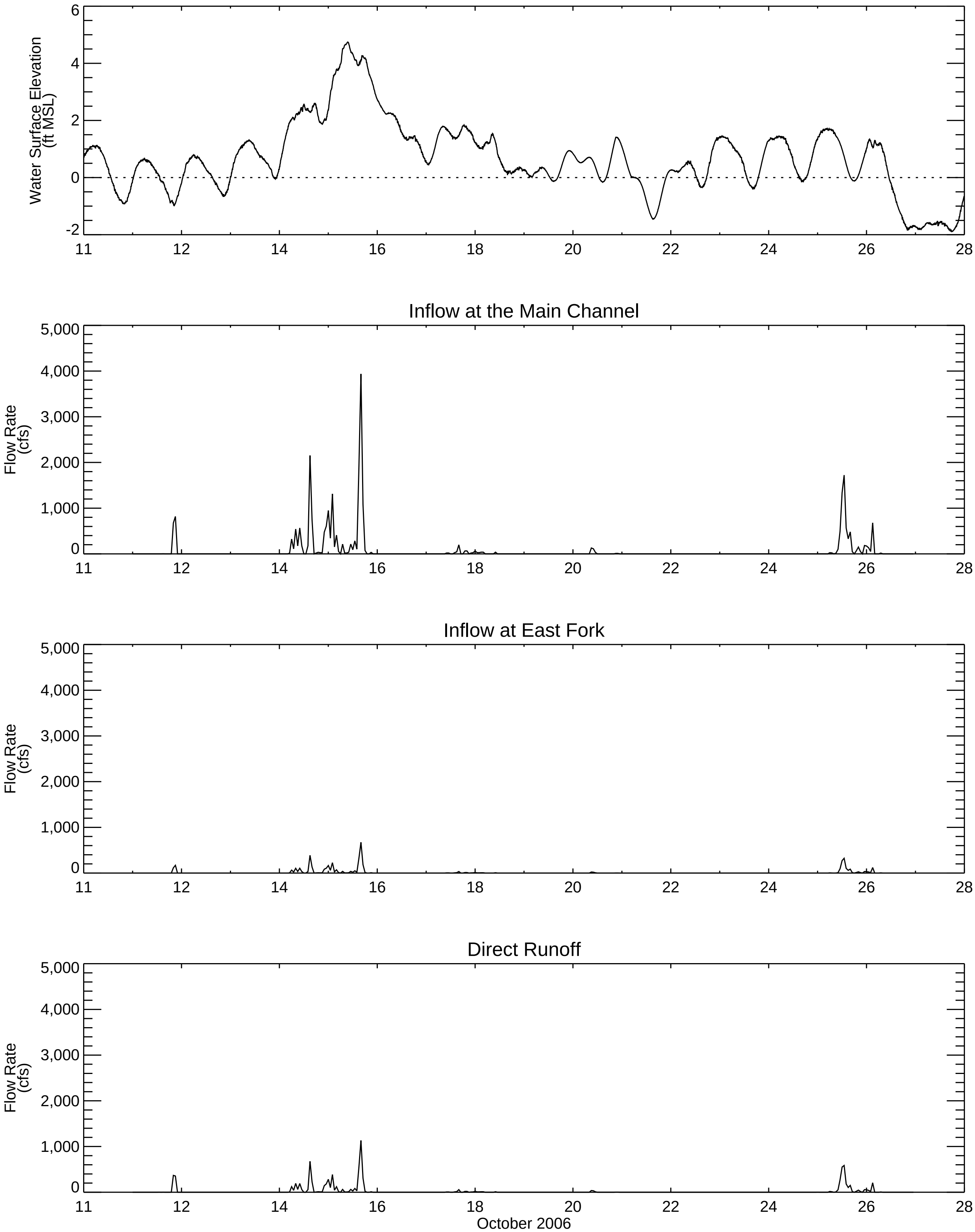


Figure 3-10

Time History of Flow Rate and Stage Height During October 2006
Patrick Bayou Remedial Investigation Report
Patrick Bayou Superfund Site Remedial Investigation, Deer Park, Texas

Note: Stage height from NOAA gauge station 8770743 (Battleship Texas State Park).
Flow predicted by watershed model.

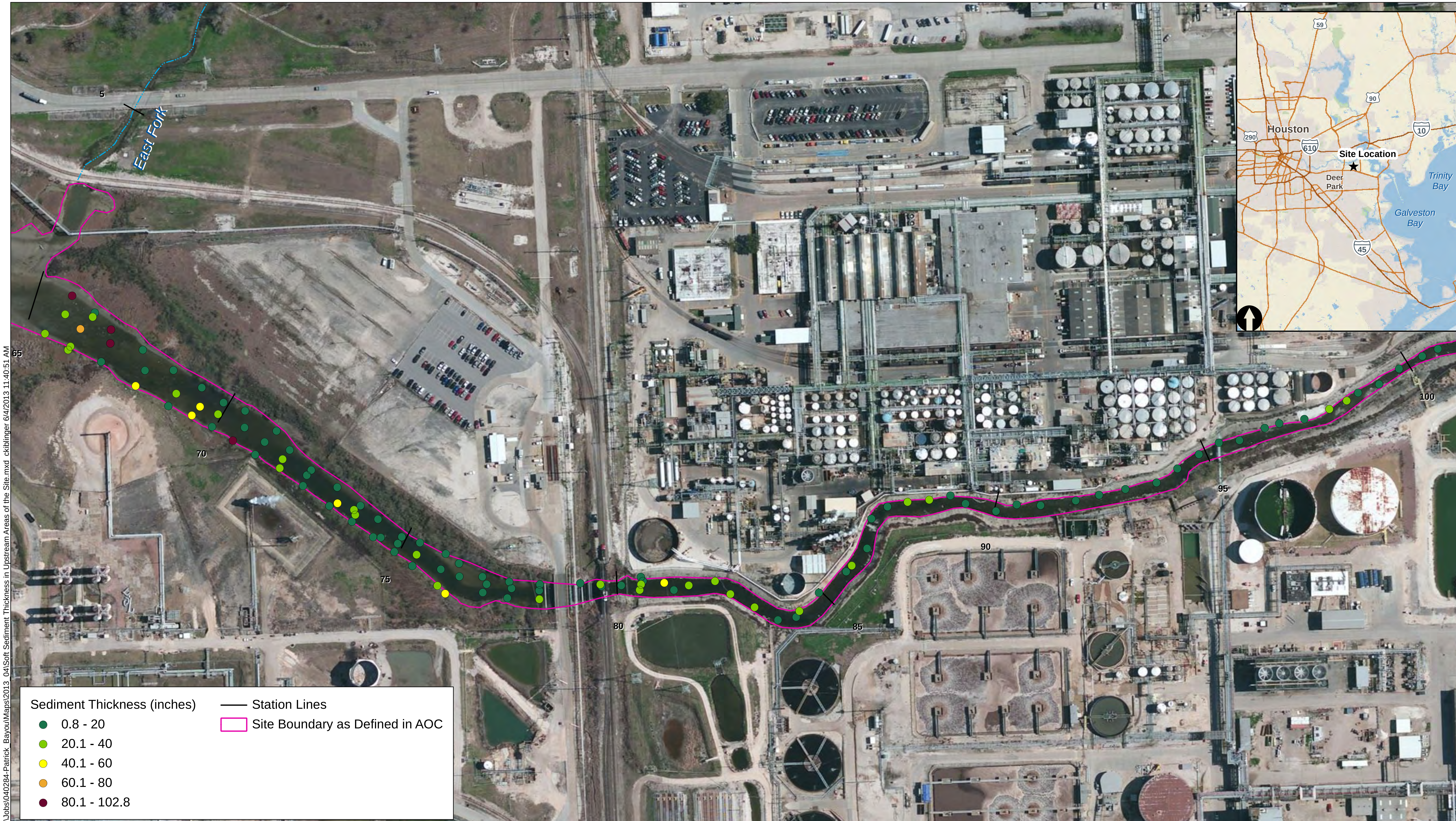
Q:\Jobs\040284-Patrick_Bayou\Maps\2013_05_RI\Sediment_Thickness_Survey.mxd ckiblinger 6/4/2013 11:14:42 AM

ANCHOR QEA

NOTES:
Station numbers from Patrick Bayou PSCR indicate length along channel in hundreds of feet.
Aerial imagery: Microsoft Bing Maps, copyright 2010 (accessed 6/4/2013.)

Feet
0 500 1,000

Figure 3-11
Sediment Thickness Survey Results for Patrick Bayou
Patrick Bayou Remedial Investigation Report
Patrick Bayou Superfund Site Remedial Investigation, Deer Park, TX



Q:\Jobs\040284-Patrick_Bayou\Maps\2013_04\Soft Sediment Thickness in Upstream Areas of the Site.mxd ckiblinger 6/4/2013 11:40:51 AM

ANCHOR QEA

NOTES:
Stations are placed in 500-foot intervals. Station numbers indicate length along channel in hundreds of feet.
Aerial imagery: Microsoft Bing Maps, copyright 2010 (accessed 6/4/2013.)

Feet
0 100 200

Figure 3-12
Soft Sediment Thickness in Upstream Areas of the Site
Patrick Bayou Remedial Investigation Report
Patrick Bayou Superfund Site Remedial Investigation, Deer Park, Texas

\\HOUL-HSAMAHA\D_Drive\Patrick_Bayou\Documents\2012_RI_Report\Figures\Sedflume_Core_Locations_130605.mxd hsamaha 6/5/2013 8:07:43 AM

NOTES:
Station numbers from Patrick Bayou PSCR indicate length along channel in hundreds of feet.
Aerial imagery: Microsoft Bing Maps, copyright 2010 (accessed 6/5/2013.)

Feet
0 500 1,000

ANCHOR QEA

Figure 3-13
Erosion Rate (Sedflume) Core Locations
Patrick Bayou Remedial Investigation Report
Patrick Bayou Superfund Site Remedial Investigation, Deer Park, Texas

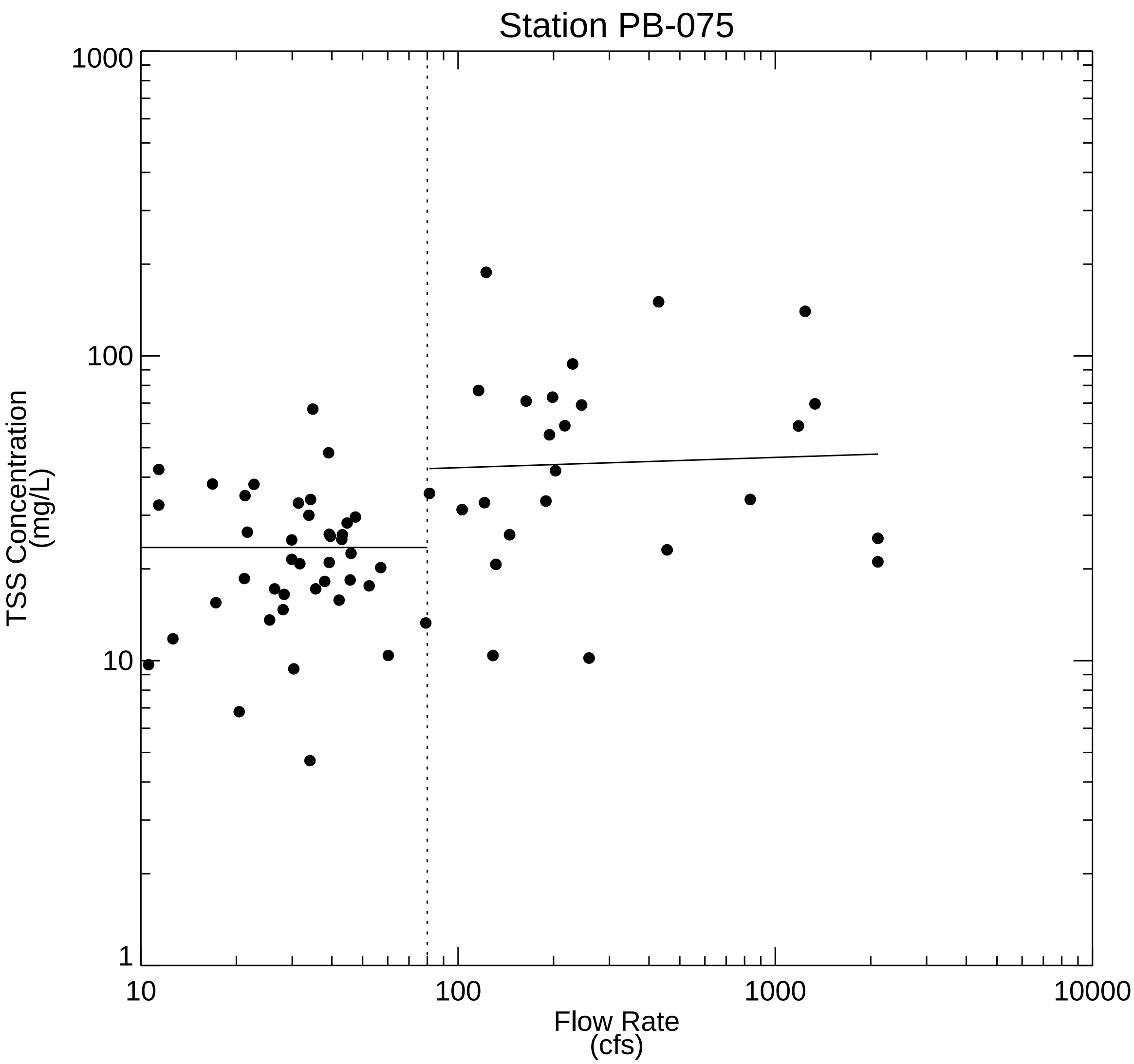


Figure 3-14

Sediment Rating Curve for Station PB-075
Patrick Bayou Remedial Investigation Report
Patrick Bayou Superfund Site Remedial Investigation, Deer Park, Texas

Note: Data collected from October 11 to November 6, 2006.

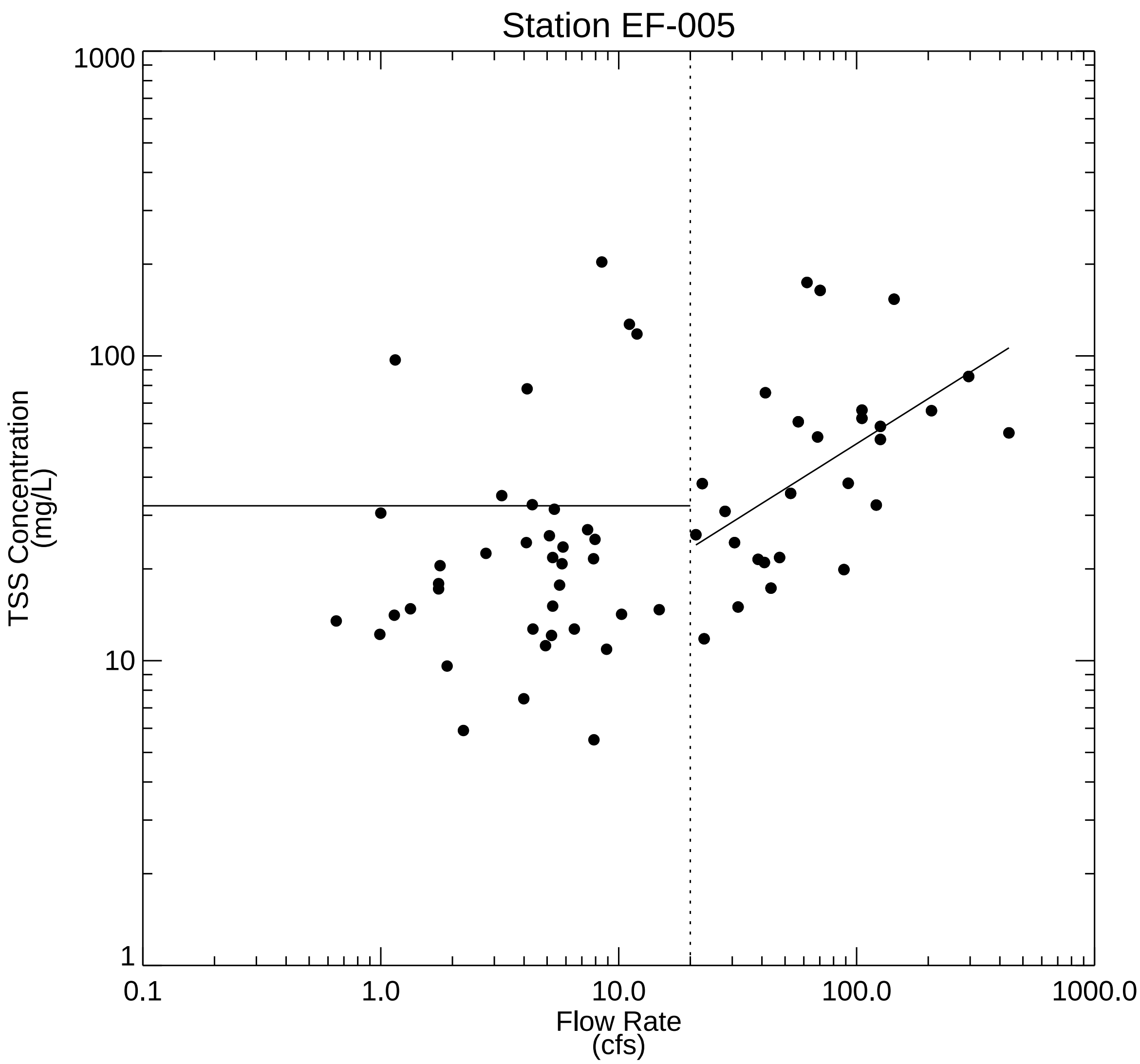


Figure 3-15

Sediment Rating Curve for Station EF-005
Patrick Bayou Remedial Investigation Report
Patrick Bayou Superfund Site Remedial Investigation, Deer Park, Texas

Note: Data collected from October 11 to November 6, 2006.

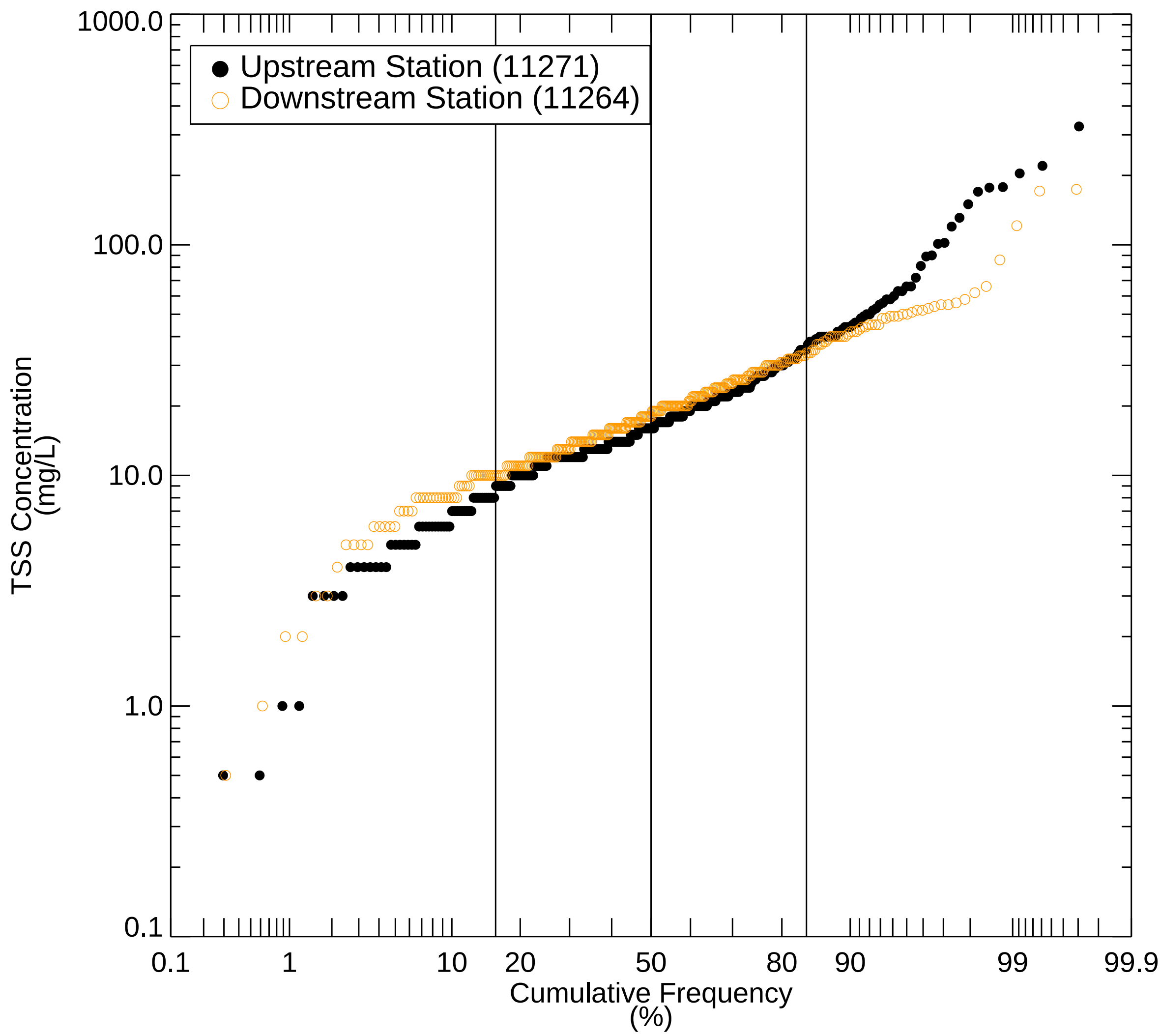
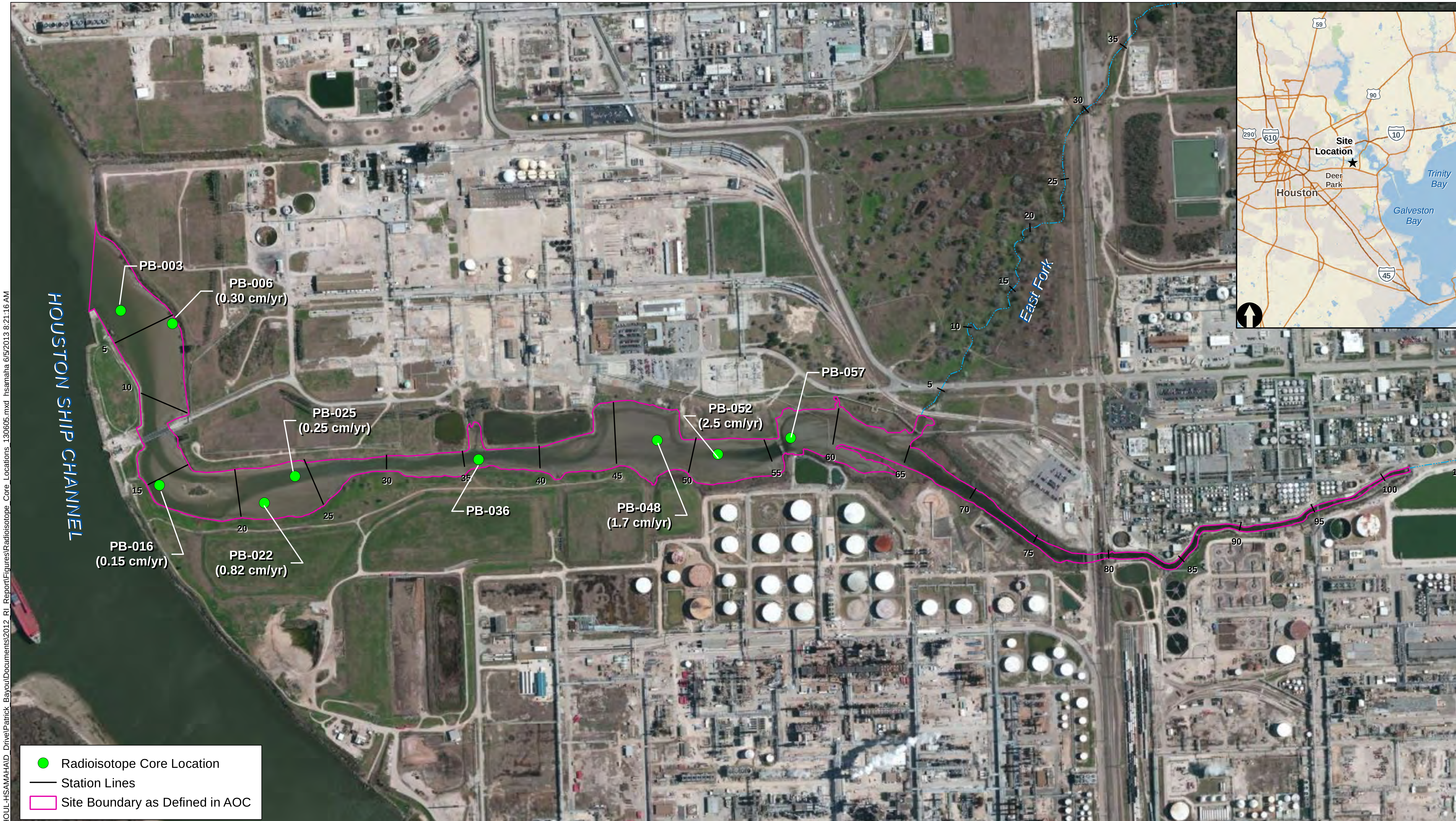


Figure 3-16

Comparison of Cumulative Frequency Distributions for Historical TSS Concentration Data Collected at Two HSC Stations
Patrick Bayou Remedial Investigation Report
Patrick Bayou Superfund Site Remedial Investigation, Deer Park, Texas

ANCHOR QEA

VKL/HS - \\aries\Montvale\Users\hsamaha\Patrick_Bayou\Documents\2012_RI_Report\Figures\HSC_TSS_prob_plot_130401.pro Wed Apr 03 16:14:35 2013



\\HOUL-HSAMAHA\D_Drive\Patrick_Bayou\Documents\2012_RI_Report\Figures\Radioisotope_Core_Locations_130605.mxd hsamaha 6/5/2013 8:21:16 AM

ANCHOR QEA

NOTES:
The number in the annotation is the estimated sedimentation rate based on [210]Pb age-dating analysis.
Station numbers from Patrick Bayou PSCR indicate length along channel in hundreds of feet.
Aerial imagery: Microsoft Bing Maps, copyright 2010 (accessed 6/5/2013.)

Feet
0 500 1,000

Figure 3-17
Radioisotope Core Sampling Locations
Patrick Bayou Remedial Investigation Report
Patrick Bayou Superfund Site Remedial Investigation, Deer Park, Texas

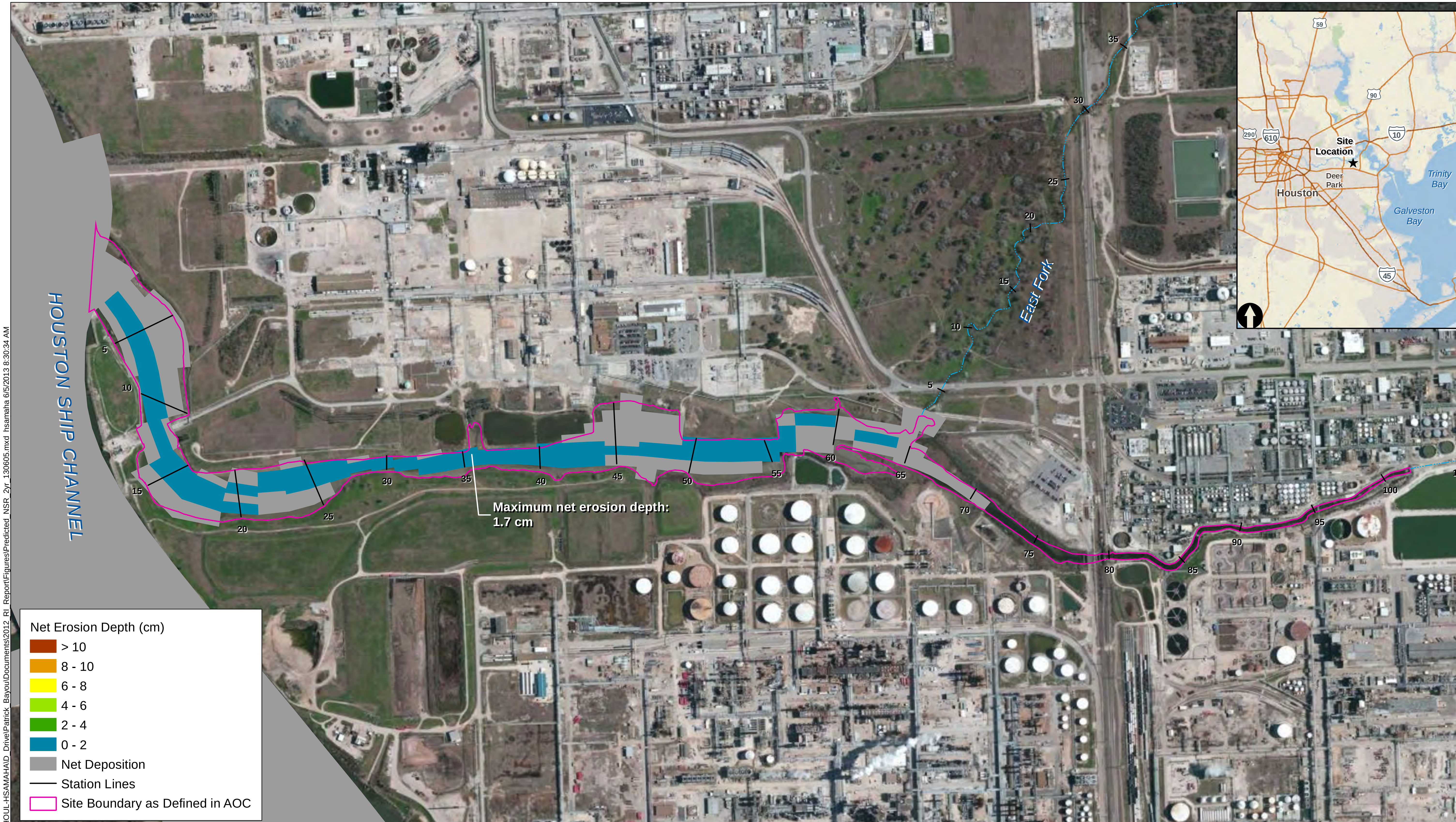
\\HOUL-HSAMAHA\D_Drive\Patrick_Bayou\Documents\2012_RI_Report\Figures\Predicted_NSR_130605.mxd hsamaha 7/17/2013 8:44:36 AM

ANCHOR QEA

NOTES:
The number in the annotation is the estimated sedimentation rate based on ^{210}Pb age-dating analysis.
Station numbers from Patrick Bayou PSCR indicate length along channel in hundreds of feet.
Aerial imagery: Microsoft Bing Maps, copyright 2010 (accessed 7/17/2013.)

Feet
0 500 1,000

Figure 3-18
Spatial Distribution of Predicted Net Sedimentation Rate
in Patrick Bayou for 14-Year Period (1993-2006)
Patrick Bayou Remedial Investigation Report
Patrick Bayou Superfund Site Remedial Investigation, Deer Park, Texas



ANCHOR QEA

NOTES:
Station numbers from Patrick Bayou PSCR indicate length along channel in hundreds of feet.
Aerial imagery: Microsoft Bing Maps, copyright 2010 (accessed 6/5/2013.)

Feet
0 500 1,000

Figure 3-19
Spatial Distribution of Predicted Net Erosion Depth During 2-year High-flow Event
Patrick Bayou Remedial Investigation Report
Patrick Bayou Superfund Site Remedial Investigation, Deer Park, Texas

\\HOUL-HSAMAHA\D Drive\Patrick Bayou\Documents\2012 RI Report\Figures\Predicted NSR 10yr 130605.mxd hsamaha 6/5/2013 8:32:04 AM

ANCHOR QEA

NOTES:
Station numbers from Patrick Bayou PSCR indicate length along channel in hundreds of feet.
Aerial imagery: Microsoft Bing Maps, copyright 2010 (accessed 6/5/2013.)

Feet
0 500 1,000

Figure 3-20
Spatial Distribution of Predicted Net Erosion Depth During 10-year High-flow Event
Patrick Bayou Remedial Investigation Report
Patrick Bayou Superfund Site Remedial Investigation, Deer Park, Texas

ANCHOR QEA

NOTES:
Station numbers from Patrick Bayou PSCR indicate length along channel in hundreds of feet.
Aerial imagery: Microsoft Bing Maps, copyright 2010 (accessed 6/5/2013.)

Feet
0 500 1,000

Figure 3-21
Spatial Distribution of Predicted Net Erosion Depth During 100-year High-flow Event
Patrick Bayou Remedial Investigation Report
Patrick Bayou Superfund Site Remedial Investigation, Deer Park, Texas

\\HOUL-HSAMAHA\D_Drive\Patrick_Bayou\Documents\2012_RI_Report\Figures\Predicted_Halftime_130605.mxd hsamaha 6/5/2013 9:36:31 AM

ANCHOR QEA

NOTES:
Predicted half-times are average values for 14-year simulation period (1993-2006).
Station numbers from Patrick Bayou PSCR indicate length along channel in hundreds of feet.
Aerial imagery: Microsoft Bing Maps, copyright 2010 (accessed 6/5/2013.)

Feet
0 500 1,000

Figure 3-22
Spatial Distribution of Predicted Half-time of Bed-source Sediment in Mixing-zone Layer (0-10cm) Sediment
Patrick Bayou Remedial Investigation Report
Patrick Bayou Superfund Site Remedial Investigation, Deer Park, Texas

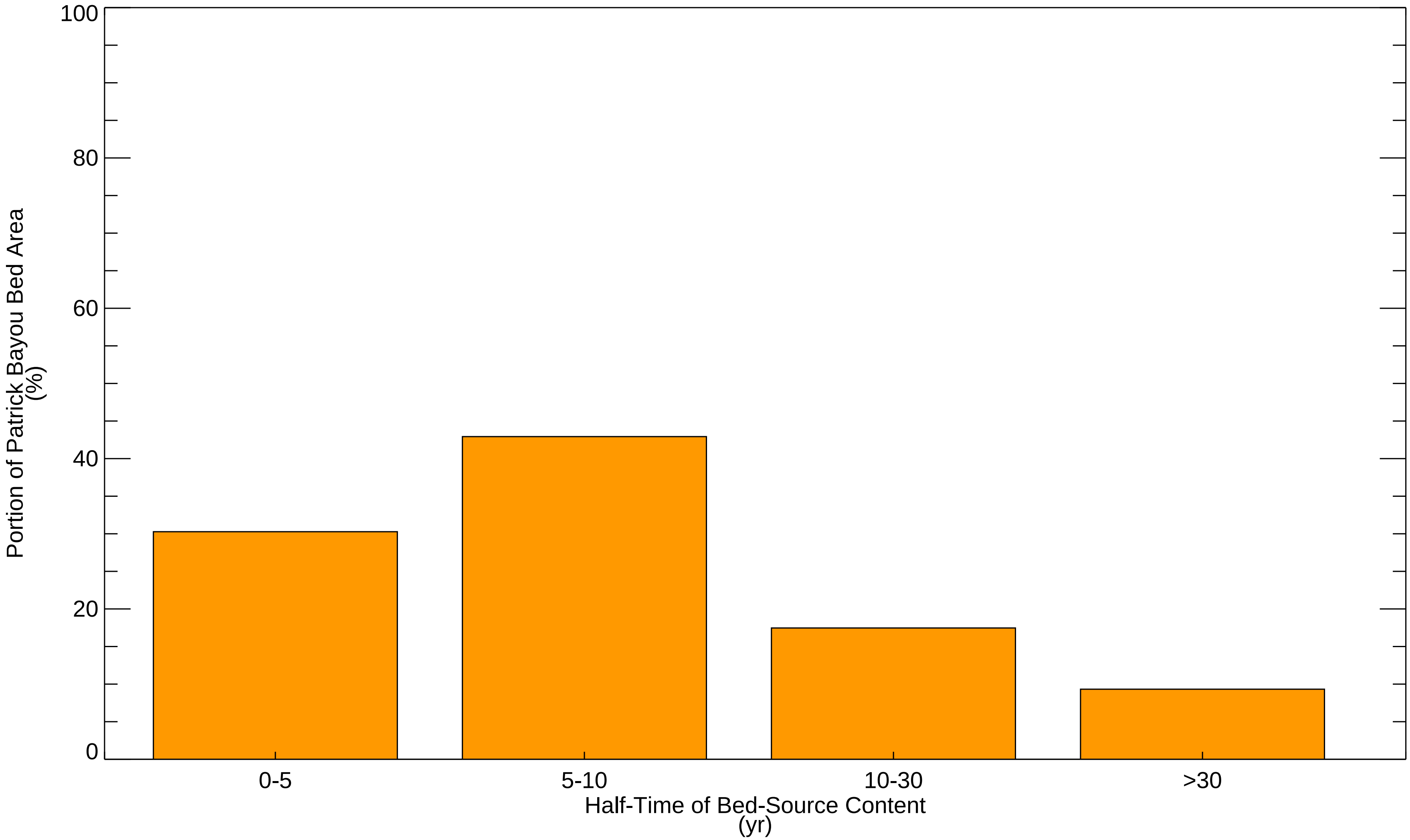
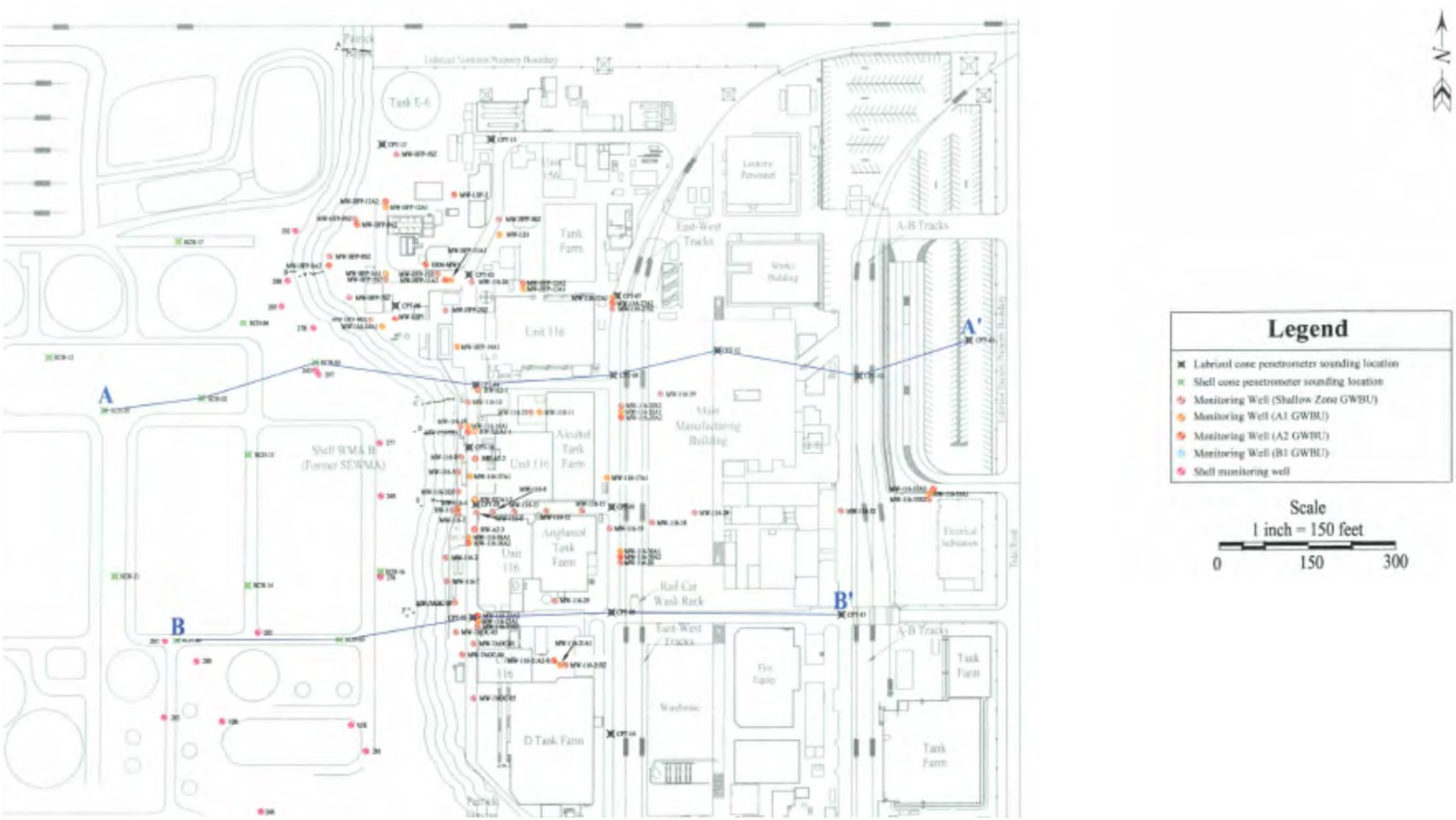


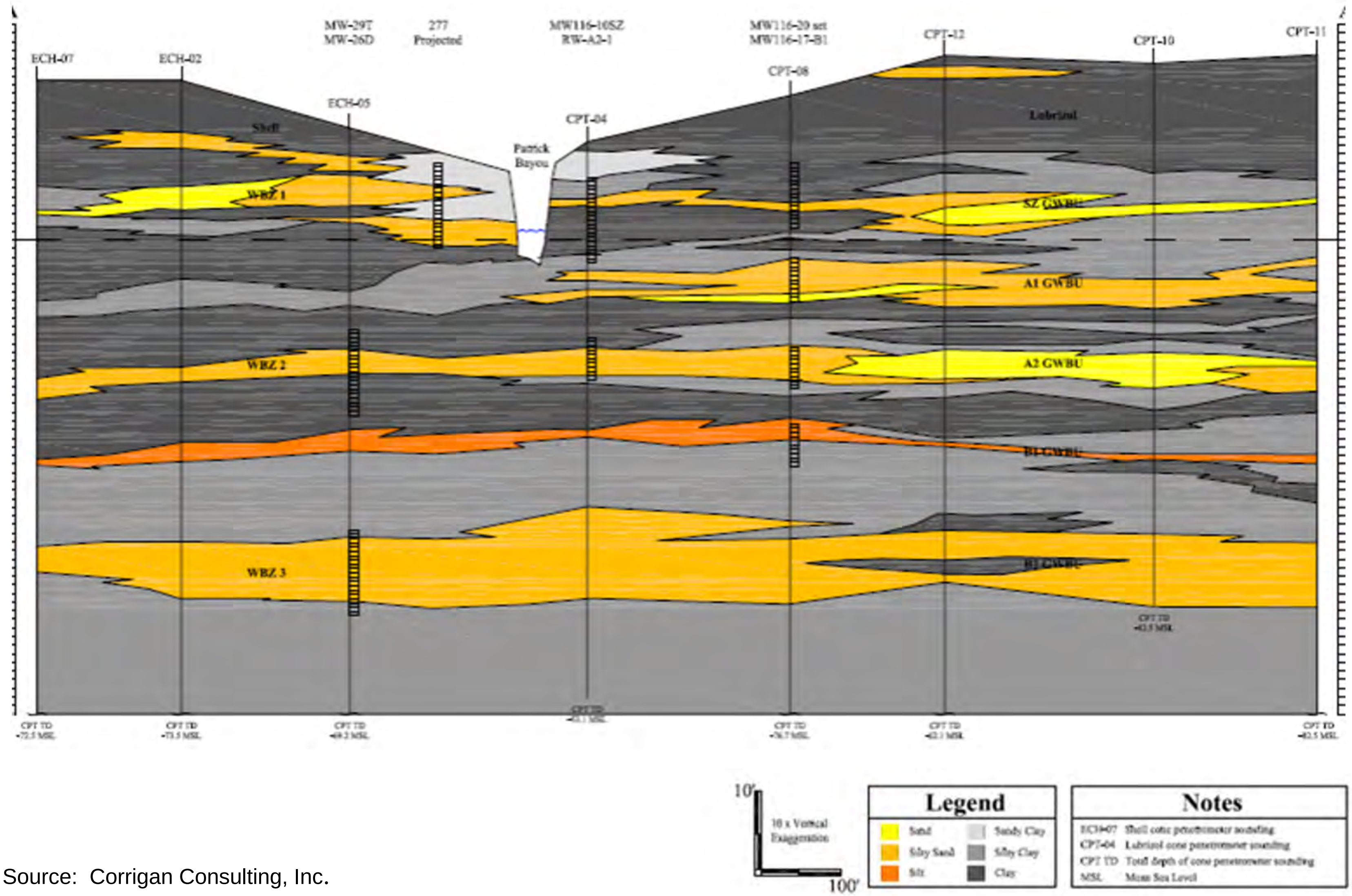
Figure 3-23

Areal Distribution of Predicted Half-Time of Bed-Source Sediment in Mixing-Zone Layer (0-10 cm)
Patrick Bayou Remedial Investigation Report
Patrick Bayou Superfund Site Remedial Investigation, Deer Park, Texas



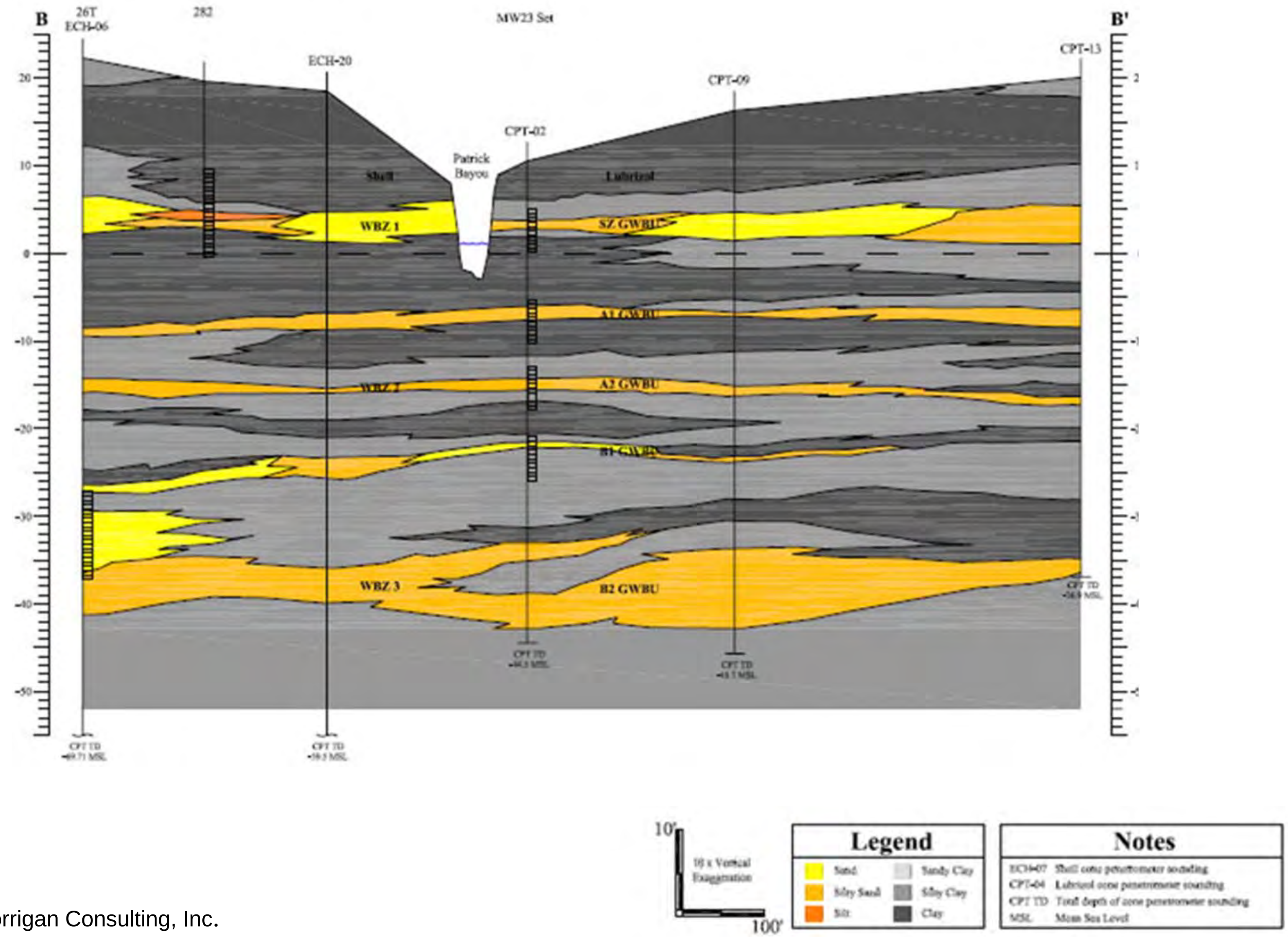
Source: Corrigan Consulting, Inc.

Figure 3-24
Location of Hydrogeologic Cross-Sections
Patrick Bayou Remedial Investigation Report
Patrick Bayou Superfund Site Remedial Investigation, Deer Park, Texas



Source: Corrigan Consulting, Inc.

Figure 3-25
Hydrogeologic Section A-A'
Patrick Bayou Remedial Investigation Report
Patrick Bayou Superfund Site Remedial Investigation, Deer Park, Texas



Source: Corrigan Consulting, Inc.

Figure 3-26
Hydrogeologic Section B-B'
Patrick Bayou Remedial Investigation Report
Patrick Bayou Superfund Site Remedial Investigation, Deer Park, Texas

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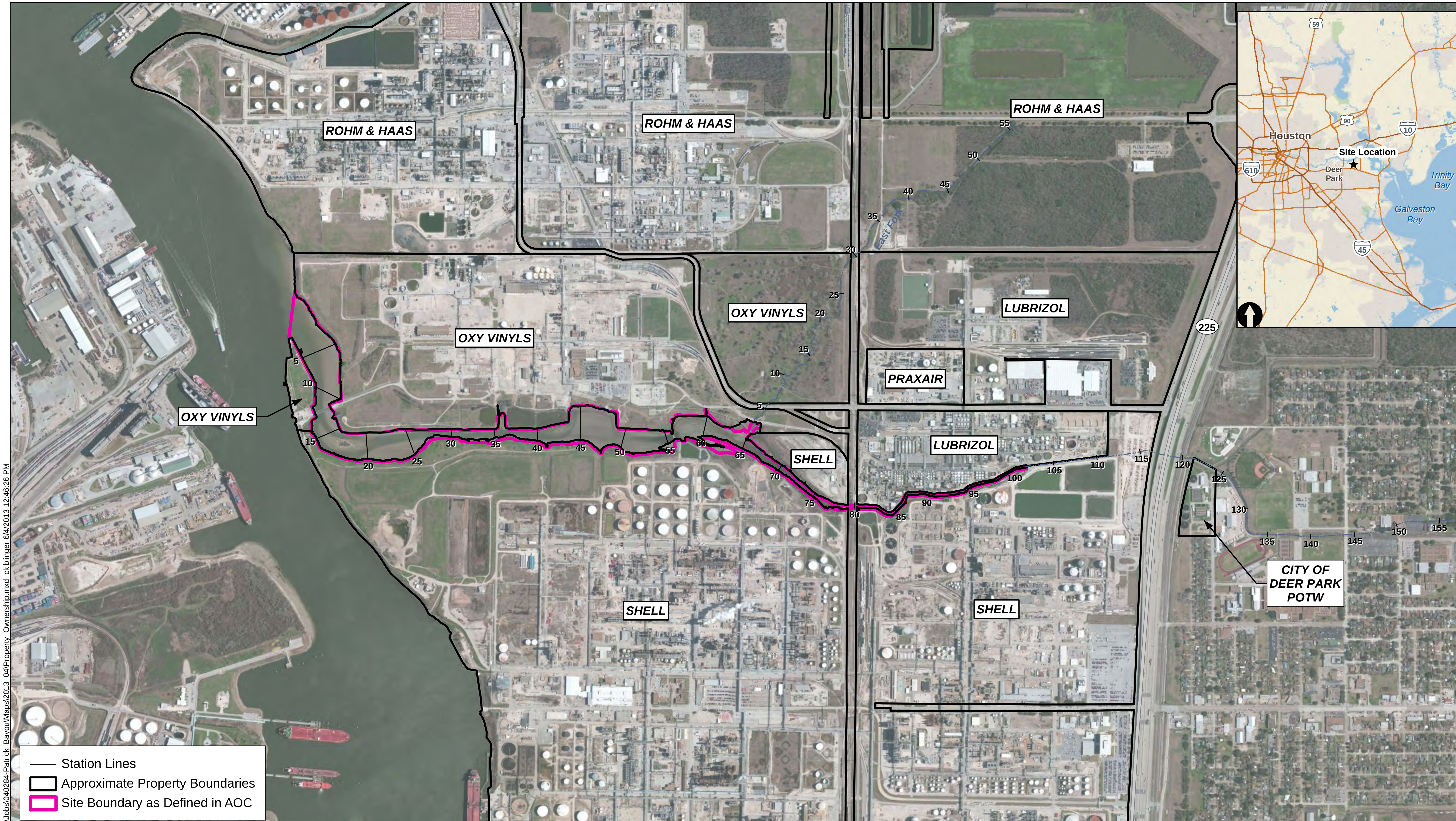
Figure 3-27
Potentiometric Surface Map for the Shallow Water Bearing Zone Near Patrick Bayou
Patrick Bayou Remedial Investigation Report
Patrick Bayou Superfund Site Remedial Investigation, Deer Park, Texas



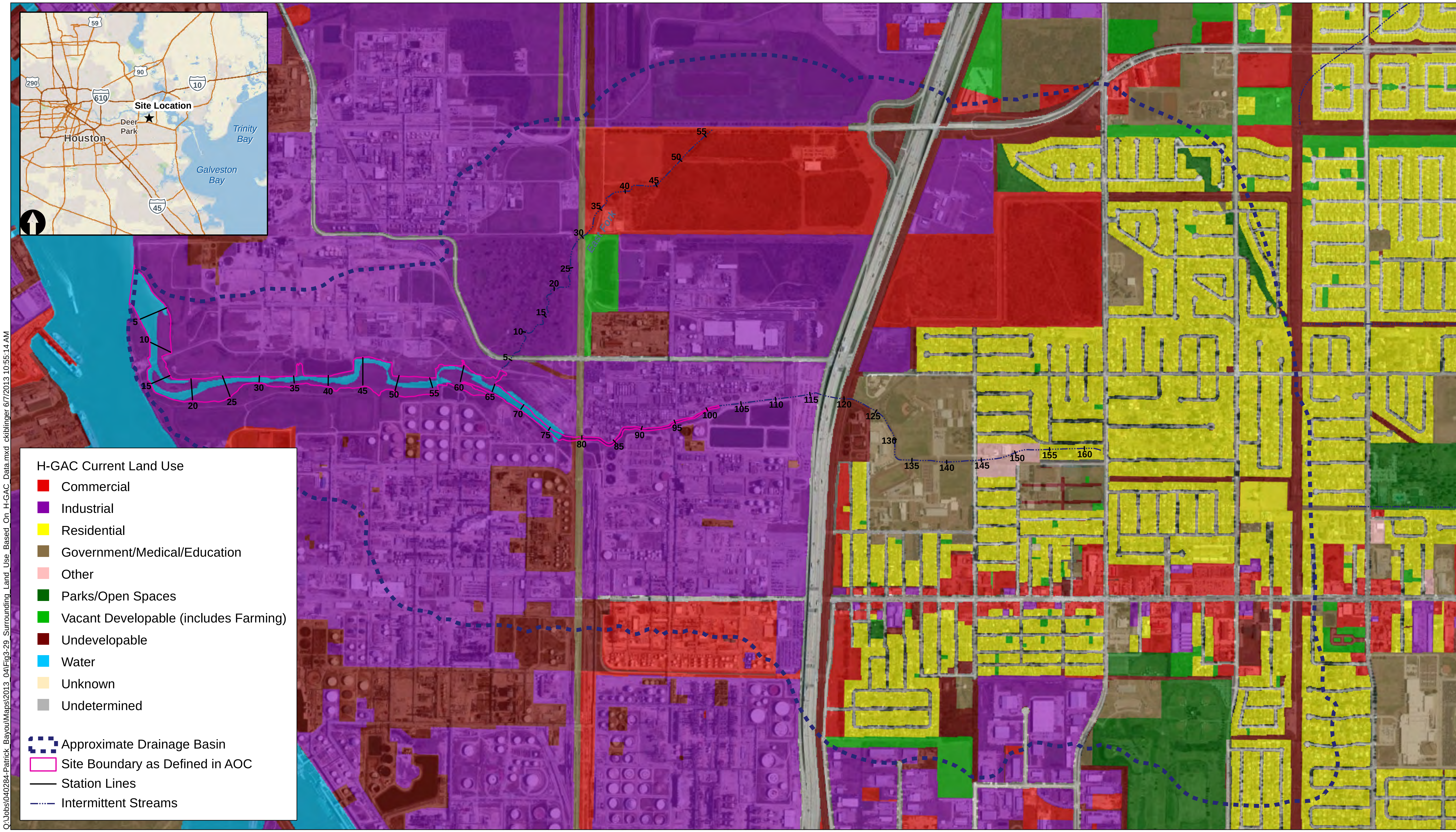
Q:\Jobs\040284-Patrick_Bayou\Maps\2013_04\Property_Ownership.mxd ckiblinger 6/4/2013 12:46:26 PM

ANCHOR QEA

NOTES:
1. Property Information from Harris County Appraisal District (HCAD).
2. Stations are placed in 500-foot intervals. Station numbers indicate length along channel in hundreds of feet.
3. Aerial imagery: Microsoft Bing Maps, copyright 2010 (accessed 6/4/2013).

Feet
0 500 1,000

Figure 3-28
Property Ownership
Patrick Bayou Remedial Investigation Report
Patrick Bayou Superfund Site Remedial Investigation, Deer Park, Texas

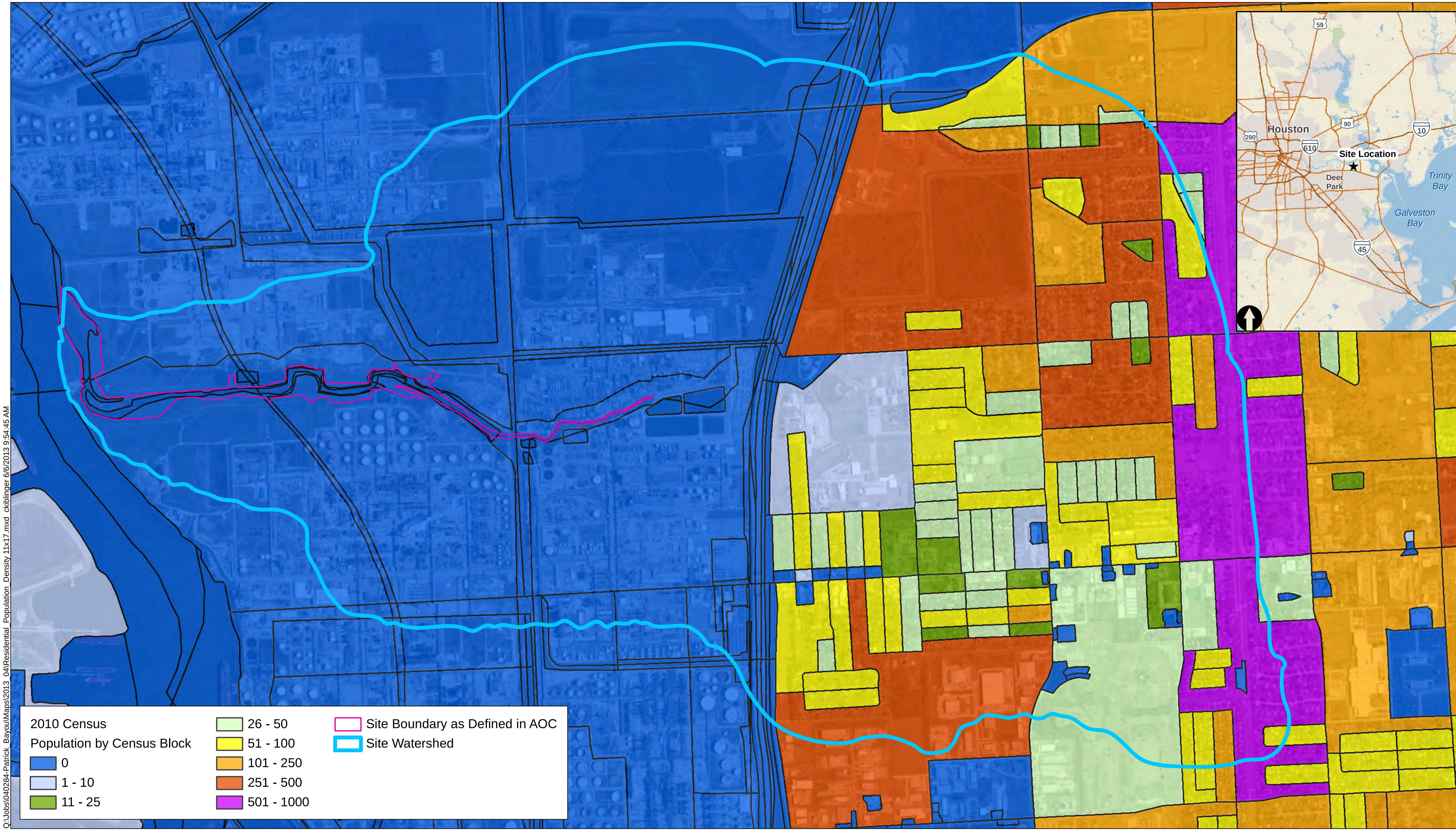


ANCHOR QEA

NOTES:
1. Land use data obtained from Houston-Galveston Area Council (HGAC). 2013. Land Use Streaming Map Service. ArcGIS link: http://arcgis02.h-gac.com/arcgis/services. Accessed 6/7/2013.
2. Stations are placed in 500-foot intervals. Station numbers indicate length along channel in hundreds of feet.
3. Aerial imagery: Microsoft Bing Maps, copyright 2010 (accessed 6/7/2013).

Feet
0 1,000 2,000

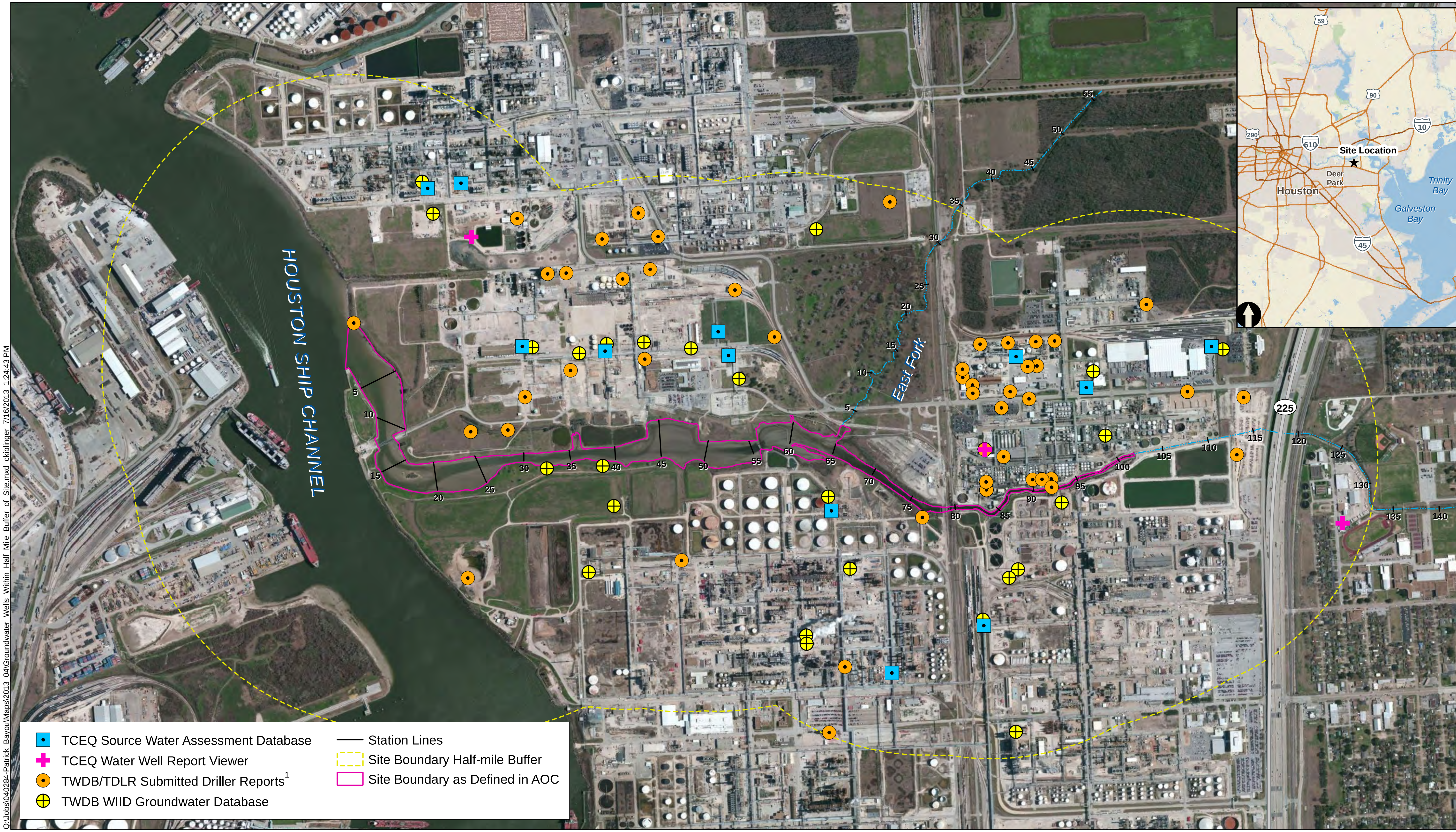
Figure 3-29
Surrounding Land Use Based on H-GAC Data
Patrick Bayou Remedial Investigation Report
Patrick Bayou Superfund Site Remedial Investigation, Deer Park, Texas



ANCHOR QEA

NOTES:
Aerial imagery: Microsoft Bing Maps, copyright 2010 (accessed 6/6/2013.)

Figure 3-30
Residential Population Density
Patrick Bayou Remedial Investigation Report
Patrick Bayou Superfund Site Remedial Investigation, Deer Park, Texas

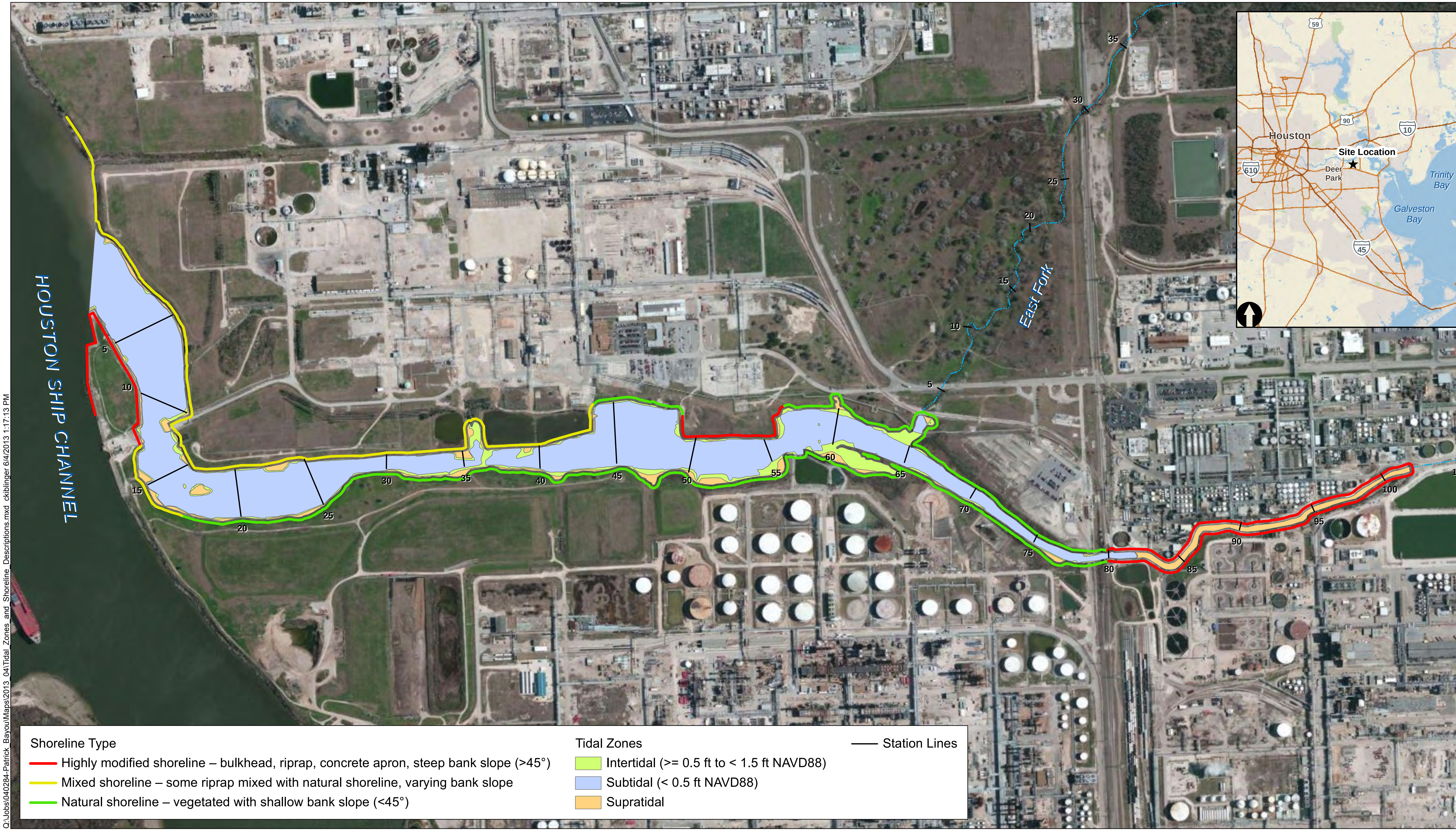


ANCHOR QEA

NOTES:
1. One well not mapped on figure. Coordinates provided were located in the Houston Ship Channel.
2. Station numbers from Patrick Bayou PSCR indicate length along channel in hundreds of feet.
3. Aerial imagery: Microsoft Bing Maps, copyright 2010 (accessed 7/16/2013).

Feet
0 500 1,000

Figure 3-31
Groundwater Wells within Half-mile Buffer of the Site
Patrick Bayou Remedial Investigation Report
Patrick Bayou Superfund Site Remedial Investigation, Deer Park, Texas



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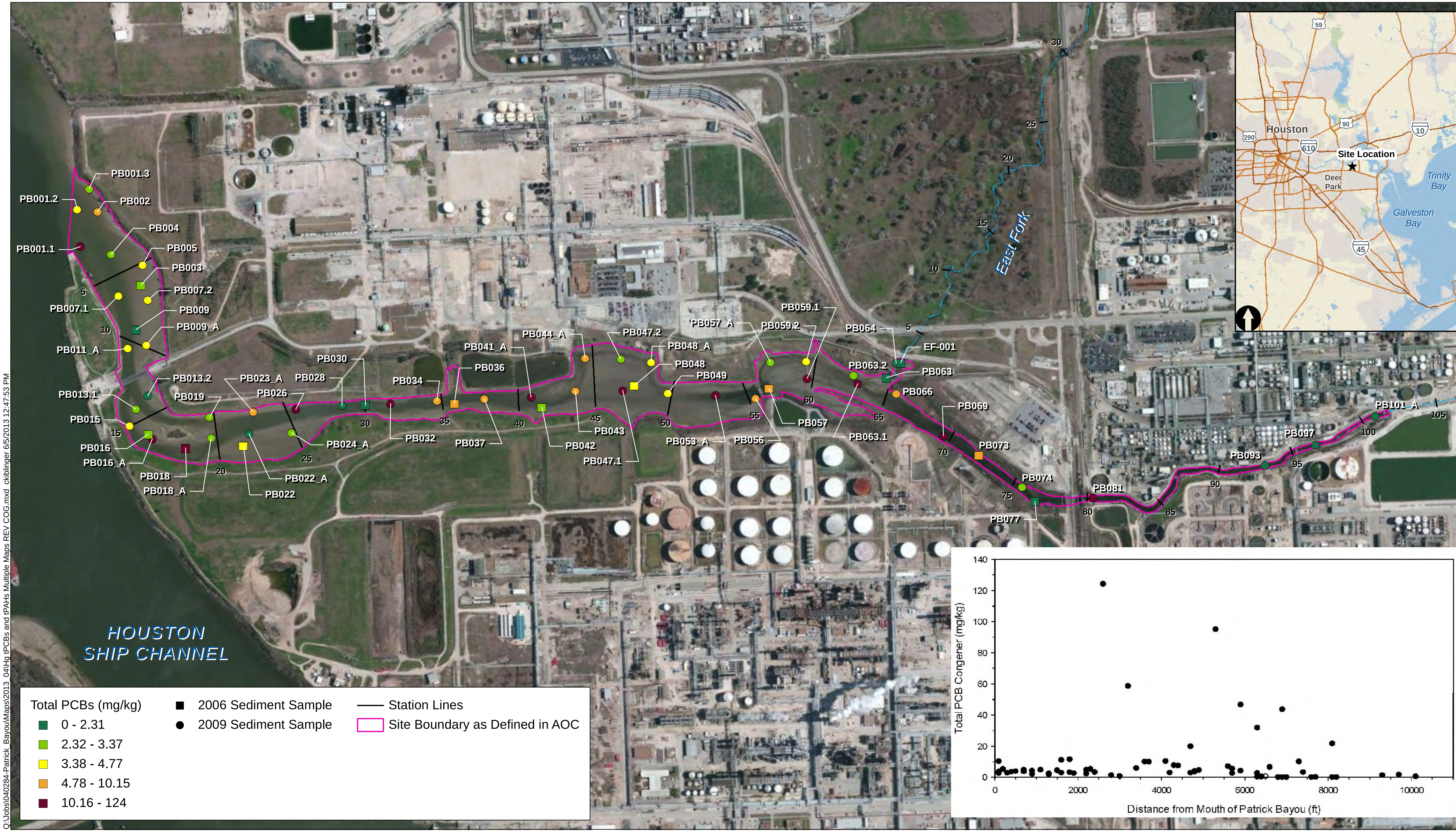
ANCHOR QEA

NOTES:
Stations are placed in 500-foot intervals. Station numbers indicate length along channel in hundreds of feet.
Aerial imagery: Microsoft Bing Maps, copyright 2010 (accessed 6/4/2013.)

Feet
0 500 1,000

Figure 3-32
Tidal Zones and Shoreline Descriptions
Patrick Bayou Remedial Investigation Report
Patrick Bayou Superfund Site Remedial Investigation, Deer Park, Texas



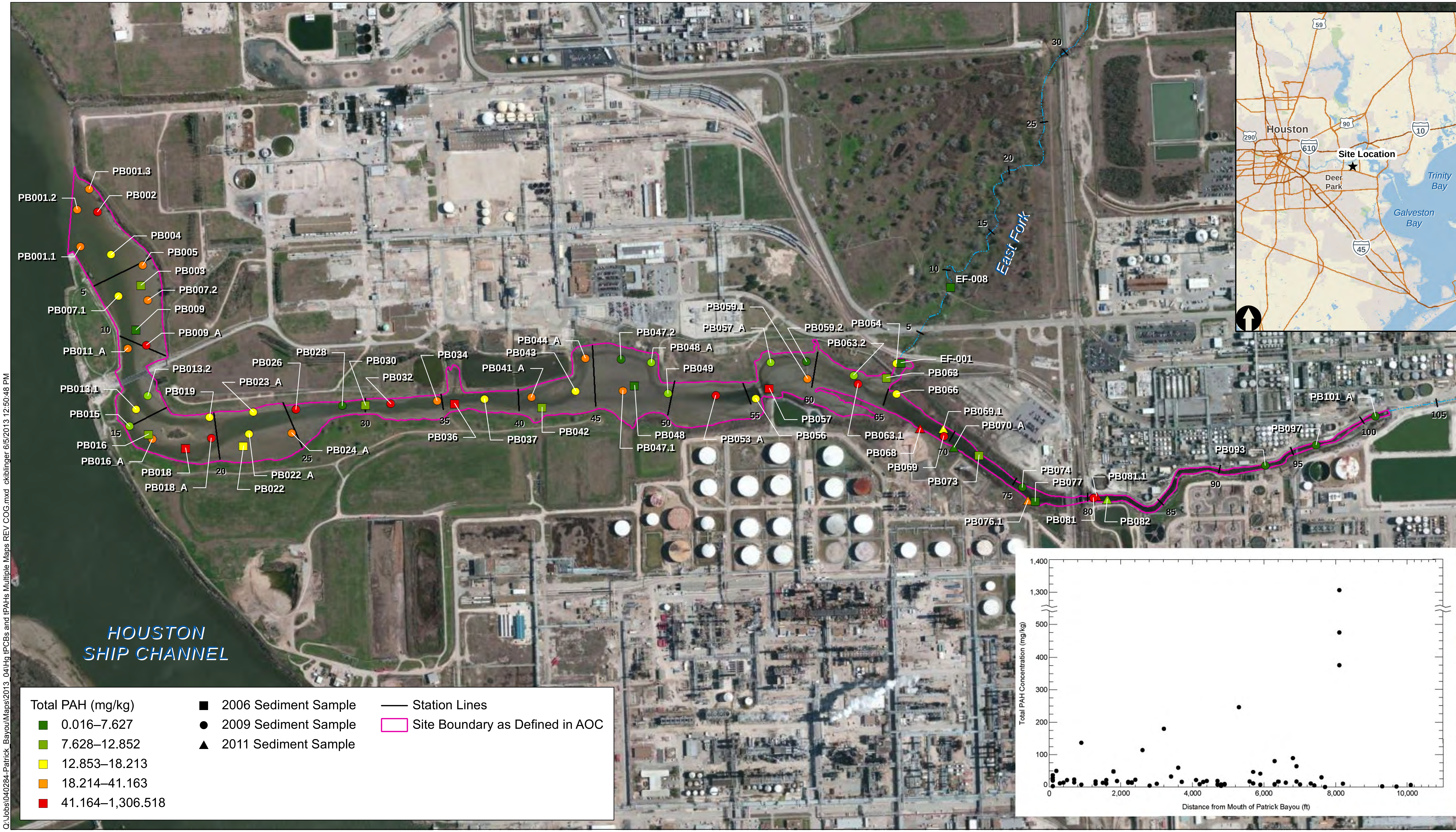
Q:\Jobs\040284-Patrick_Bayou\Maps\2013_04\Hg tPCBs and tPAHs Multiple Maps REV COG.mxd ckiblinger 6/5/2013 12:47:53 PM

ANCHOR QEA

NOTES:
Stations are placed in 500-foot intervals. Station numbers indicate length along channel in hundreds of feet.
Aerial imagery: Microsoft Bing Maps, copyright 2010 (accessed 6/5/2013.)

Feet
0 500 1,000

Figure 4-1
Total PCB Results in Surface Sediment Samples
Patrick Bayou Remedial Investigation Report
Patrick Bayou Superfund Site Remedial Investigation, Deer Park, Texas



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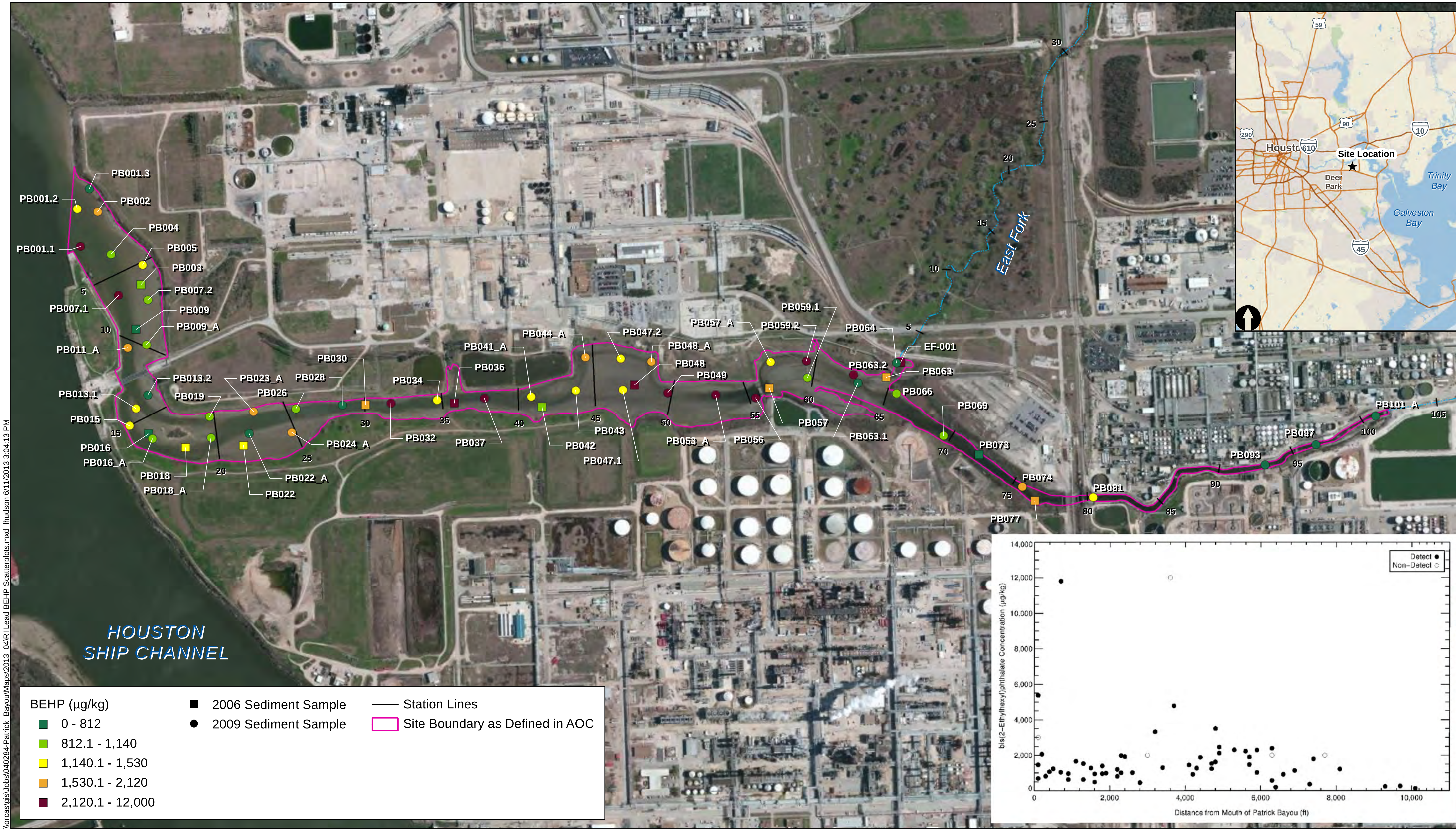
ANCHOR QEA

NOTES:
Stations are placed in 500-foot intervals. Station numbers indicate length along channel in hundreds of feet.
Aerial imagery: Microsoft Bing Maps, copyright 2010 (accessed 6/5/2013.)

Feet
0 500 1,000

Figure 4-2
Total PAH Results in Surface Sediment Samples
Patrick Bayou Remedial Investigation Report
Patrick Bayou Superfund Site Remedial Investigation, Deer Park, Texas

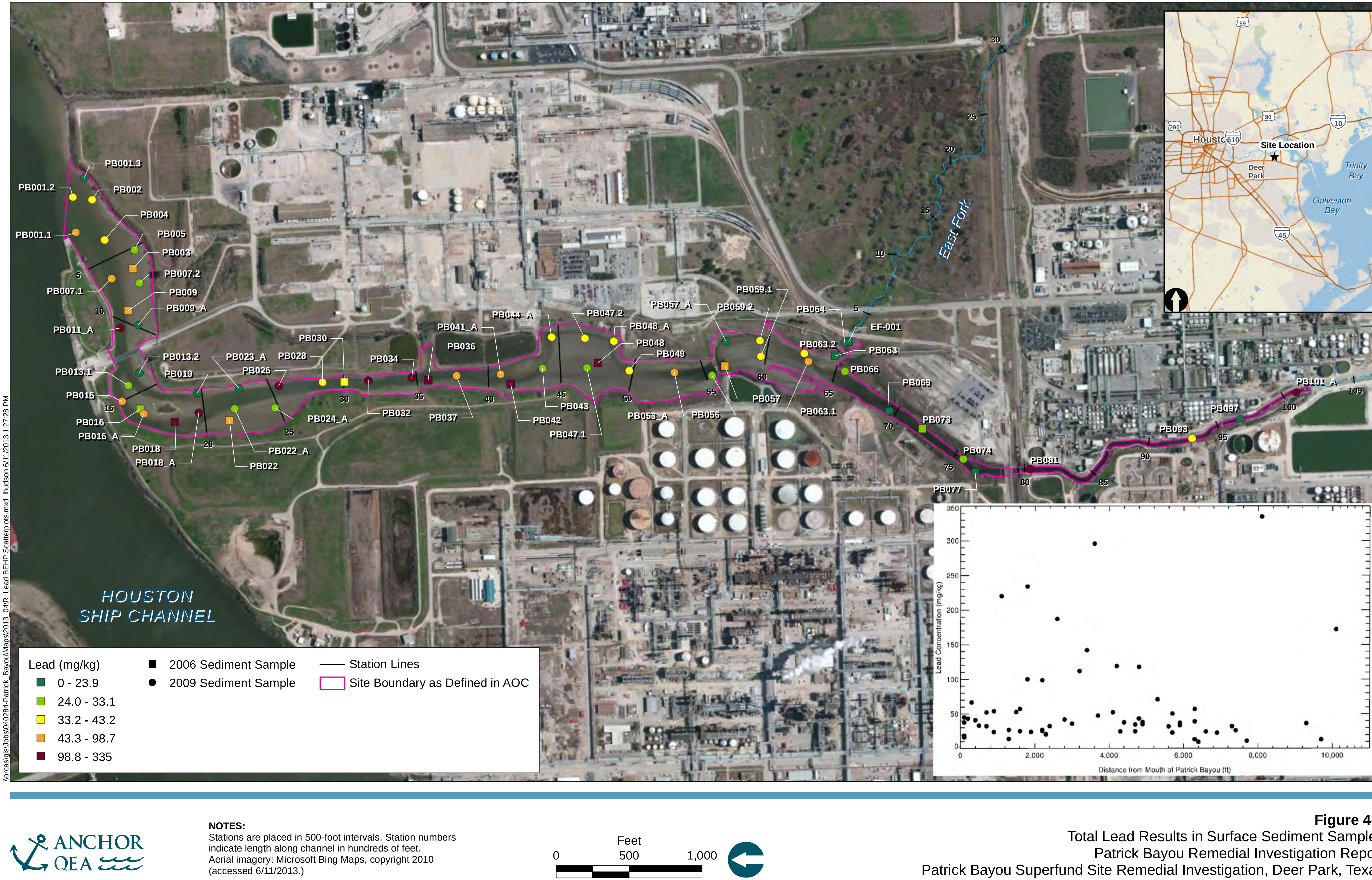


ANCHOR QEA

NOTES:
Stations are placed in 500-foot intervals. Station numbers indicate length along channel in hundreds of feet.
Aerial imagery: Microsoft Bing Maps, copyright 2010 (accessed 6/11/2013.)

Feet
0 500 1,000

Figure 4-3
Total BEHP Results in Surface Sediment Samples
Patrick Bayou Remedial Investigation Report
Patrick Bayou Superfund Site Remedial Investigation, Deer Park, Texas



NOTES:
Stations are placed in 500-foot intervals. Station numbers indicate length along channel in hundreds of feet.
Aerial imagery: Microsoft Bing Maps, copyright 2010 (accessed 6/11/2013.)

Figure 4-4
Total Lead Results in Surface Sediment Samples
Patrick Bayou Remedial Investigation Report
Patrick Bayou Superfund Site Remedial Investigation, Deer Park, Texas

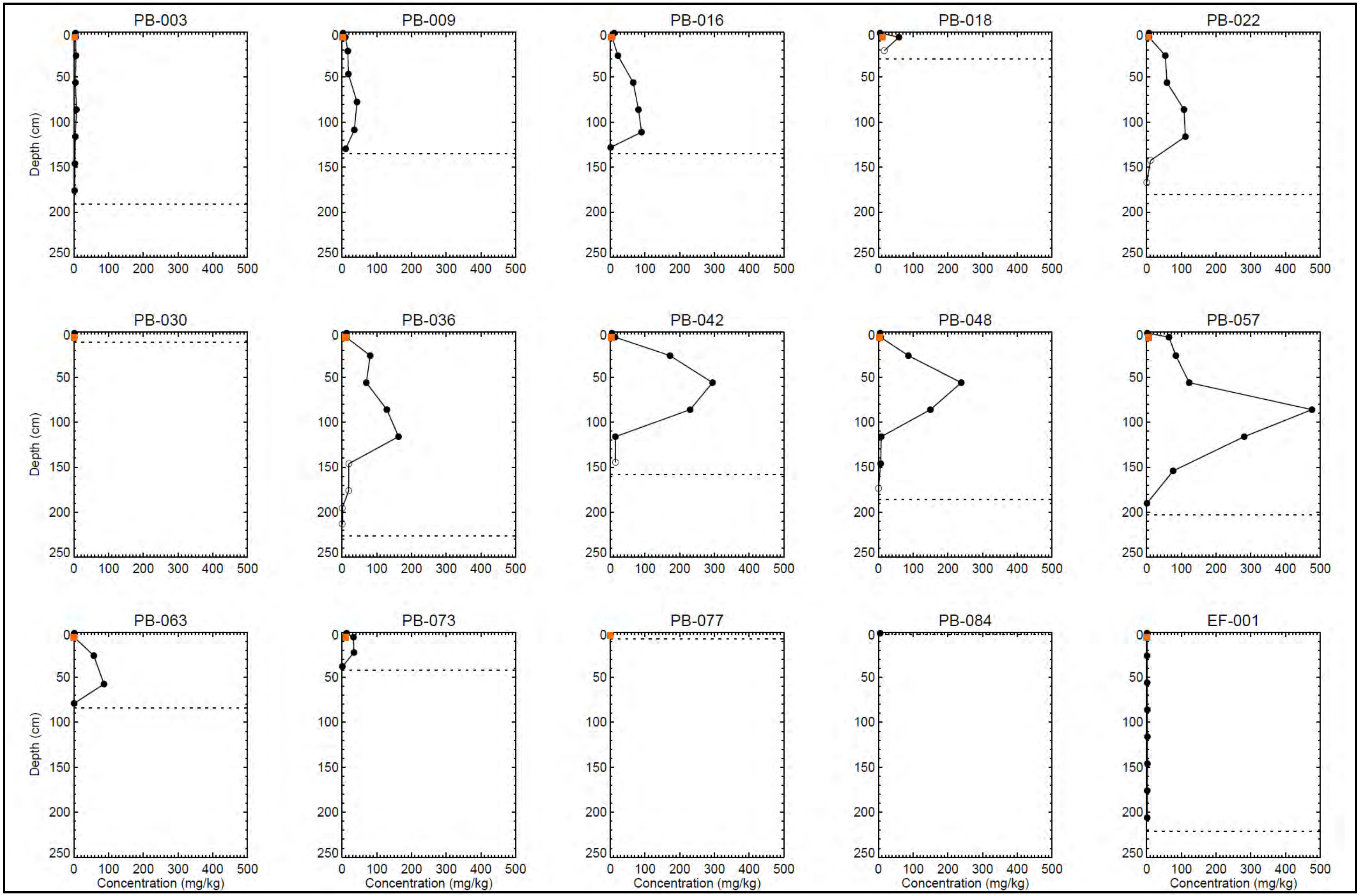
Q:\Jobs\040284-Patrick_Bayou\Maps\2013_04\Subsurface Sampling Locations.mxd ckiblinger 6/7/2013 1:07:35 PM

ANCHOR QEA

NOTES:
Stations are placed in 500-foot intervals. Station numbers indicate length along channel in hundreds of feet.
Aerial imagery: Microsoft Bing Maps, copyright 2010 (accessed 6/7/2013.)

Feet
0 500 1,000

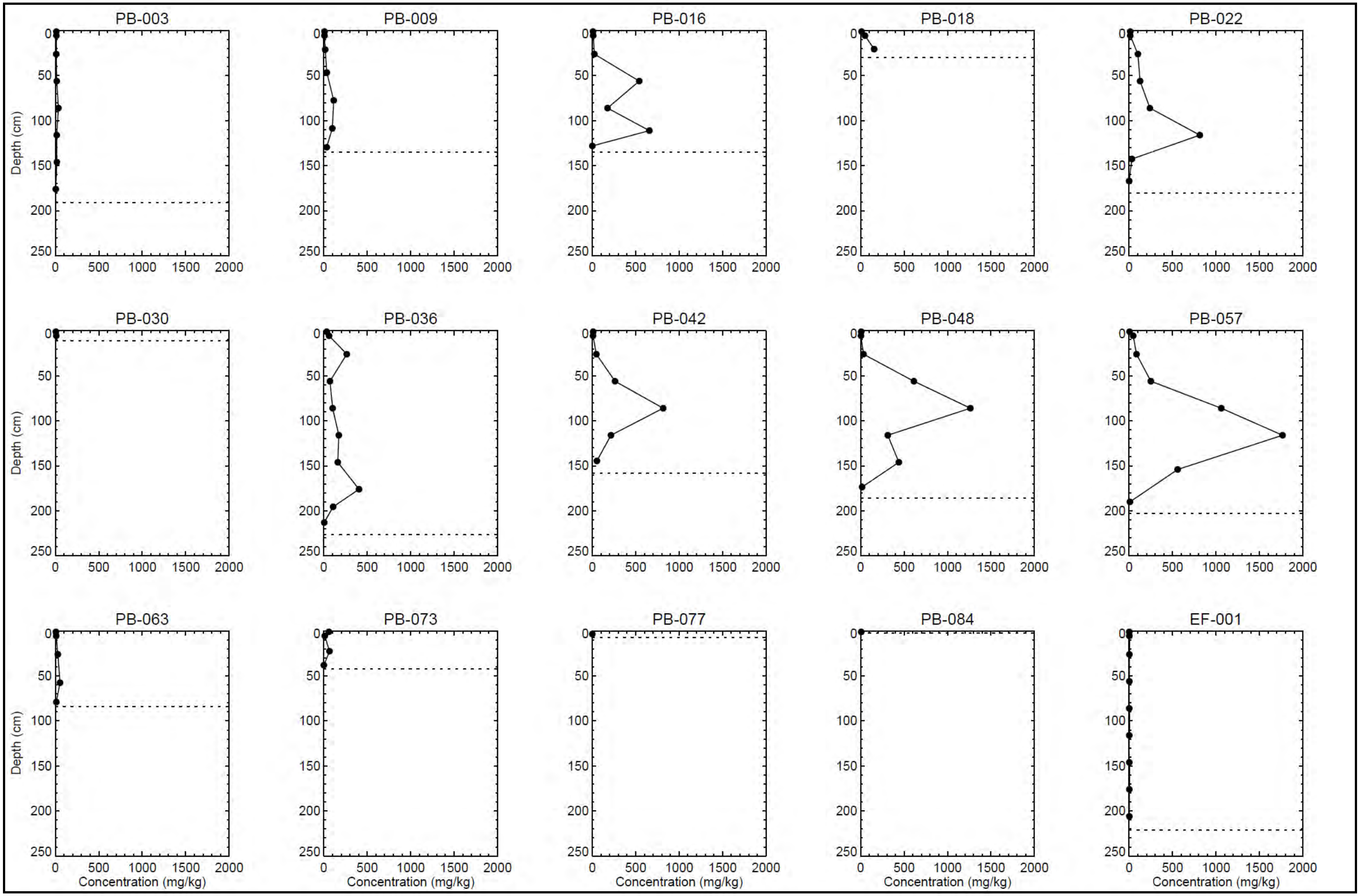
Figure 4-5
Subsurface Sampling Locations
Patrick Bayou Remedial Investigation Report
Patrick Bayou Superfund Site Remedial Investigation, Deer Park, Texas



● Aroclor ■ congener

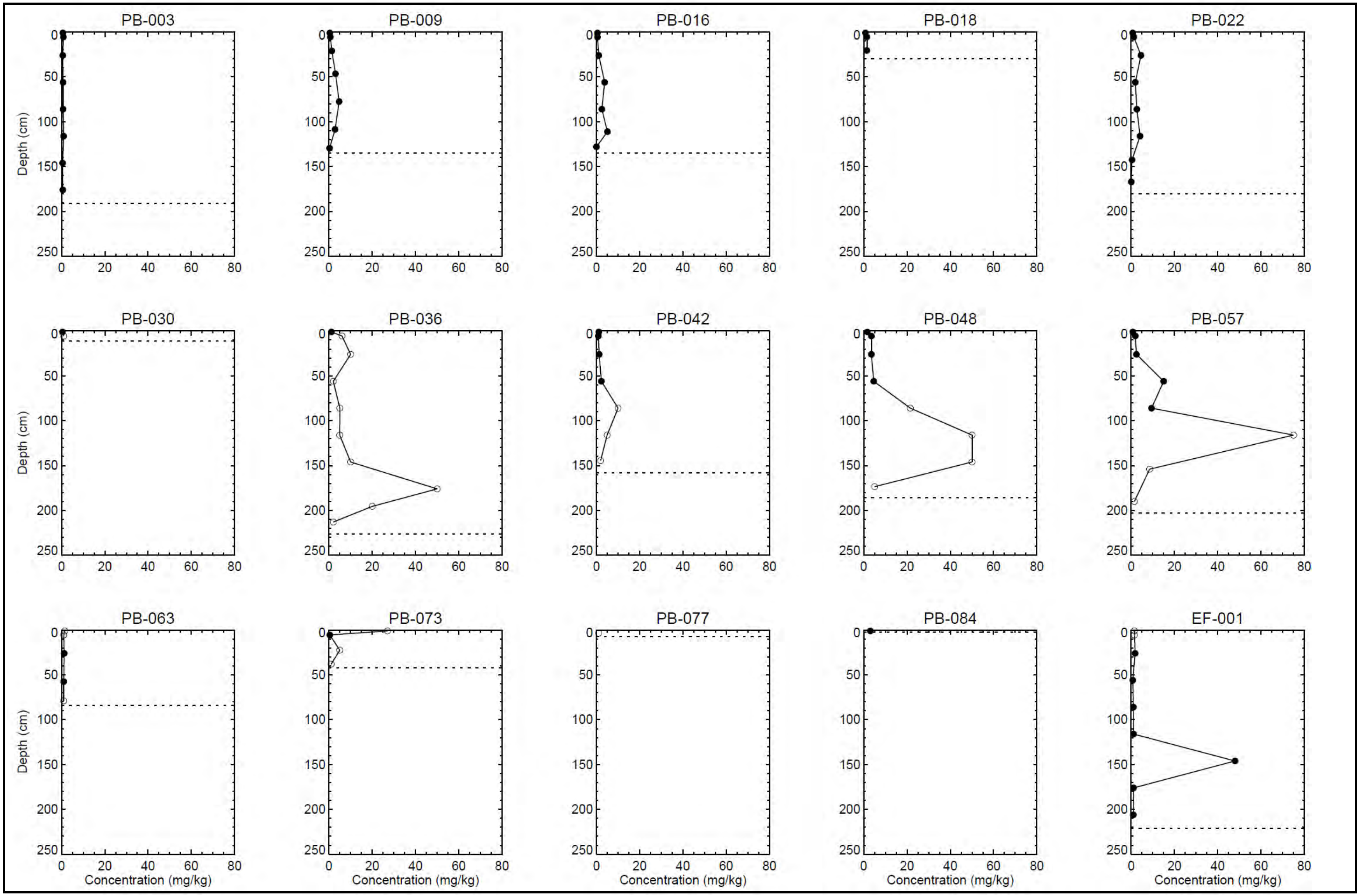
NOTES:
Cores were collected in October 2006; values are plotted at mid-depth, with non-detects shown as open symbols at half the detection limit.
Horizontal dotted line indicates approximate core depth.

Figure 4-6
Vertical Distribution of Total PCBs in Patrick Bayou
Patrick Bayou Remedial Investigation Report
Patrick Bayou Superfund Site Remedial Investigation, Deer Park, Texas



NOTES:
Cores were collected in October 2006; values are plotted at mid-depth, with non-detects shown as open symbols at half the detection limit.
Horizontal dotted line indicates approximate core depth.

Figure 4-7
Vertical Distribution of Total PAH in Patrick Bayou
Patrick Bayou Remedial Investigation Report
Patrick Bayou Superfund Site Remedial Investigation, Deer Park, Texas



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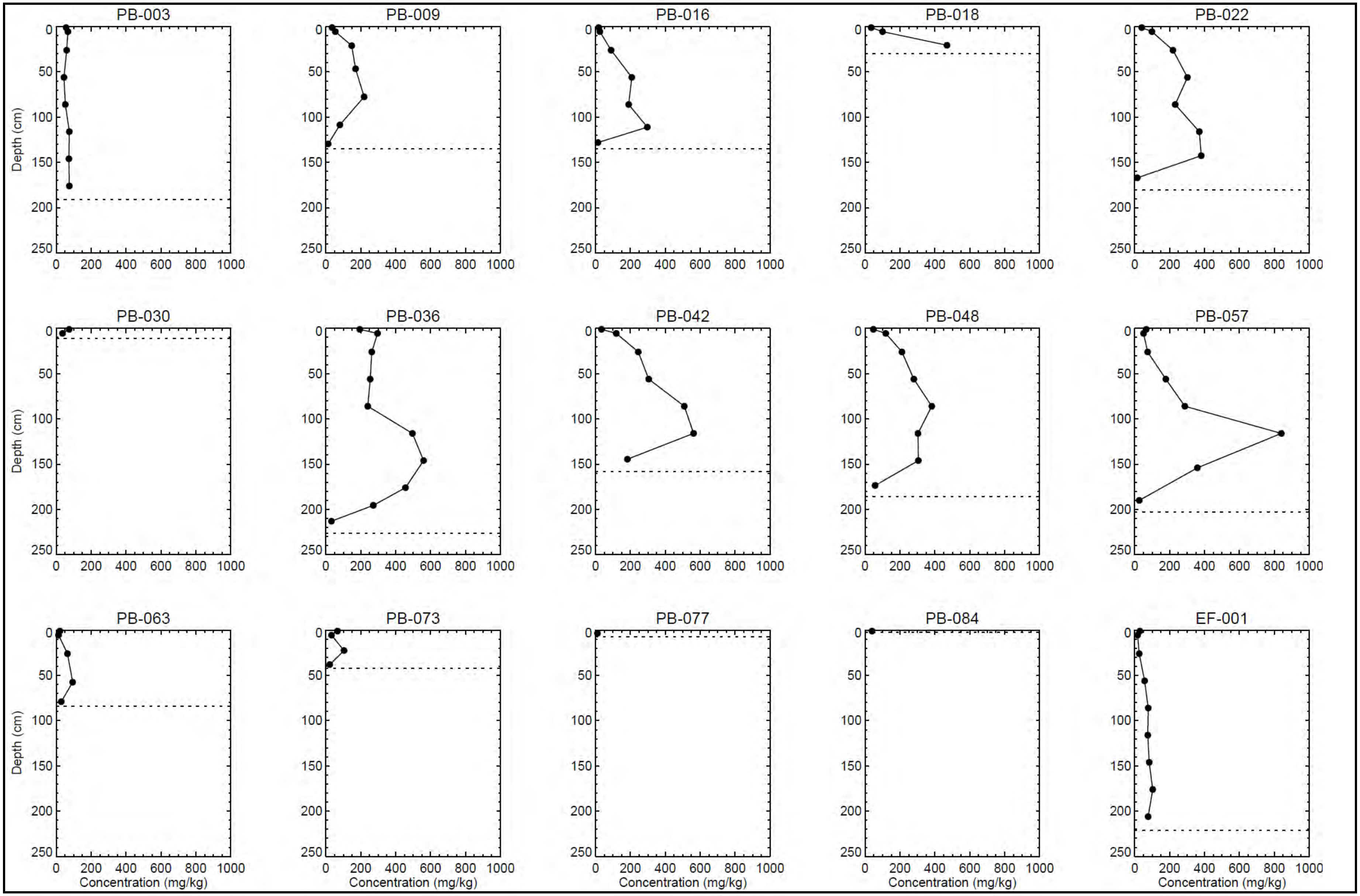
ANCHOR QEA

NOTES:
Cores were collected in October 2006; values are plotted at mid-depth, with non-detects shown as open symbols at half the detection limit.
Horizontal dotted line indicates approximate core depth.

Figure 4-8
Vertical Distribution of Bis(2-Ethylhexyl)phthalate in Patrick Bayou
Patrick Bayou Remedial Investigation Report
Patrick Bayou Superfund Site Remedial Investigation, Deer Park, Texas



ANCHOR QEA

NOTES:
Cores were collected in October 2006; values are plotted at mid-depth, with non-detects shown as open symbols at half the detection limit.
Horizontal dotted line indicates approximate core depth.

Figure 4-9
Vertical Distribution of Lead in Patrick Bayou
Patrick Bayou Remedial Investigation Report
Patrick Bayou Superfund Site Remedial Investigation, Deer Park, Texas

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ANCHOR QEA

NOTES:
Stations are placed in 500-foot intervals. Station numbers indicate length along channel in hundreds of feet.
Aerial imagery: Microsoft Bing Maps, copyright 2010 (accessed 6/7/2013.)

Feet
0 500 1,000

Figure 4-10
Total PCB Results in Porewater Samples
Patrick Bayou Remedial Investigation Report
Patrick Bayou Superfund Site Remedial Investigation, Deer Park, Texas

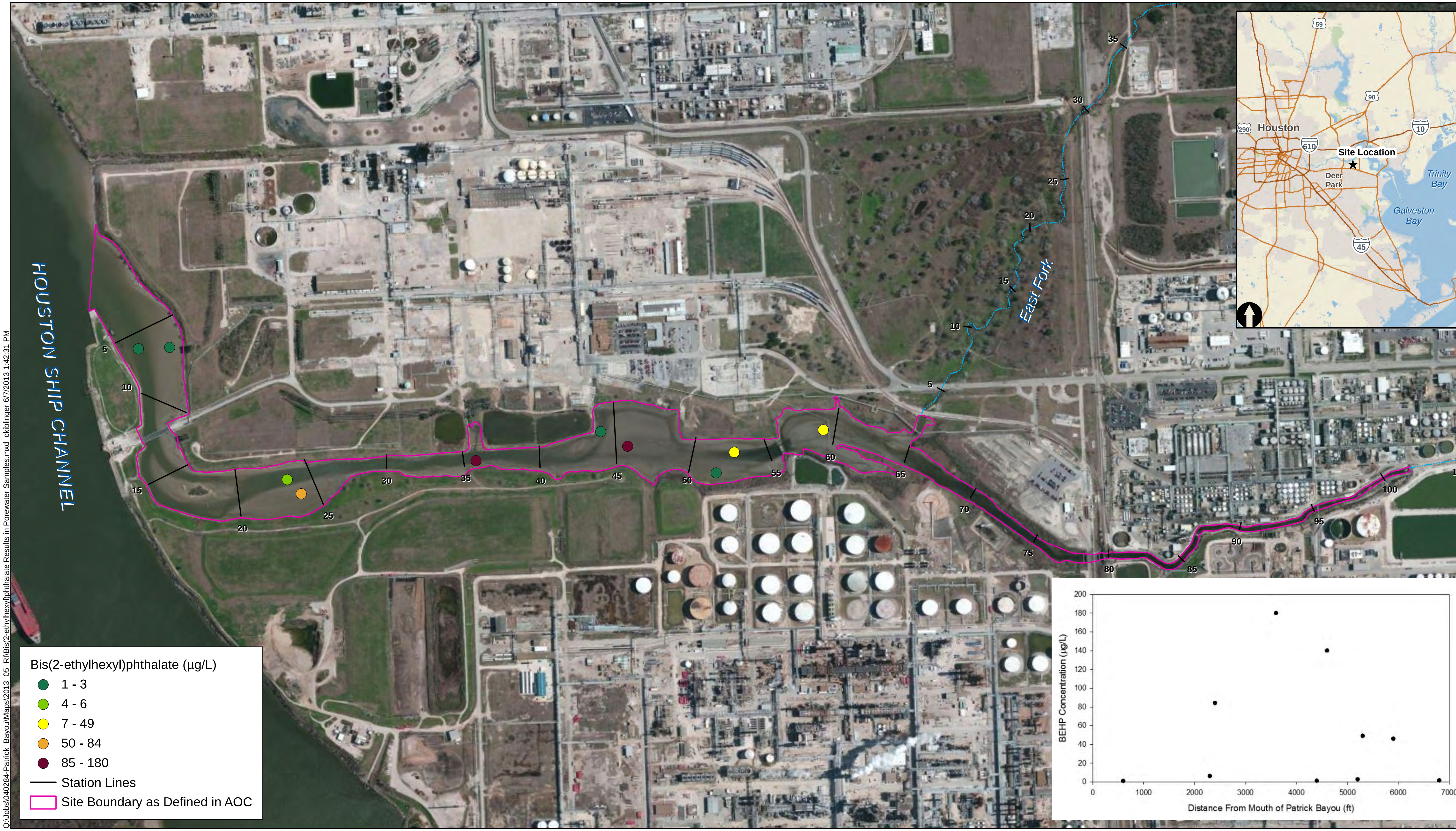
Q:\Jobs\040284-Patrick_Bayou\Maps\2013_04\Hg tPCBs and tPAHs Multiple Maps REV COG.mxd ckiblinger 6/7/2013 1:35:36 PM

ANCHOR QEA

NOTES:
Stations are placed in 500-foot intervals. Station numbers indicate length along channel in hundreds of feet.
Aerial imagery: Microsoft Bing Maps, copyright 2010 (accessed 6/7/2013.)

Feet
0 500 1,000

Figure 4-11
Total PAH Results in Porewater Samples
Patrick Bayou Remedial Investigation Report
Patrick Bayou Superfund Site Remedial Investigation, Deer Park, Texas

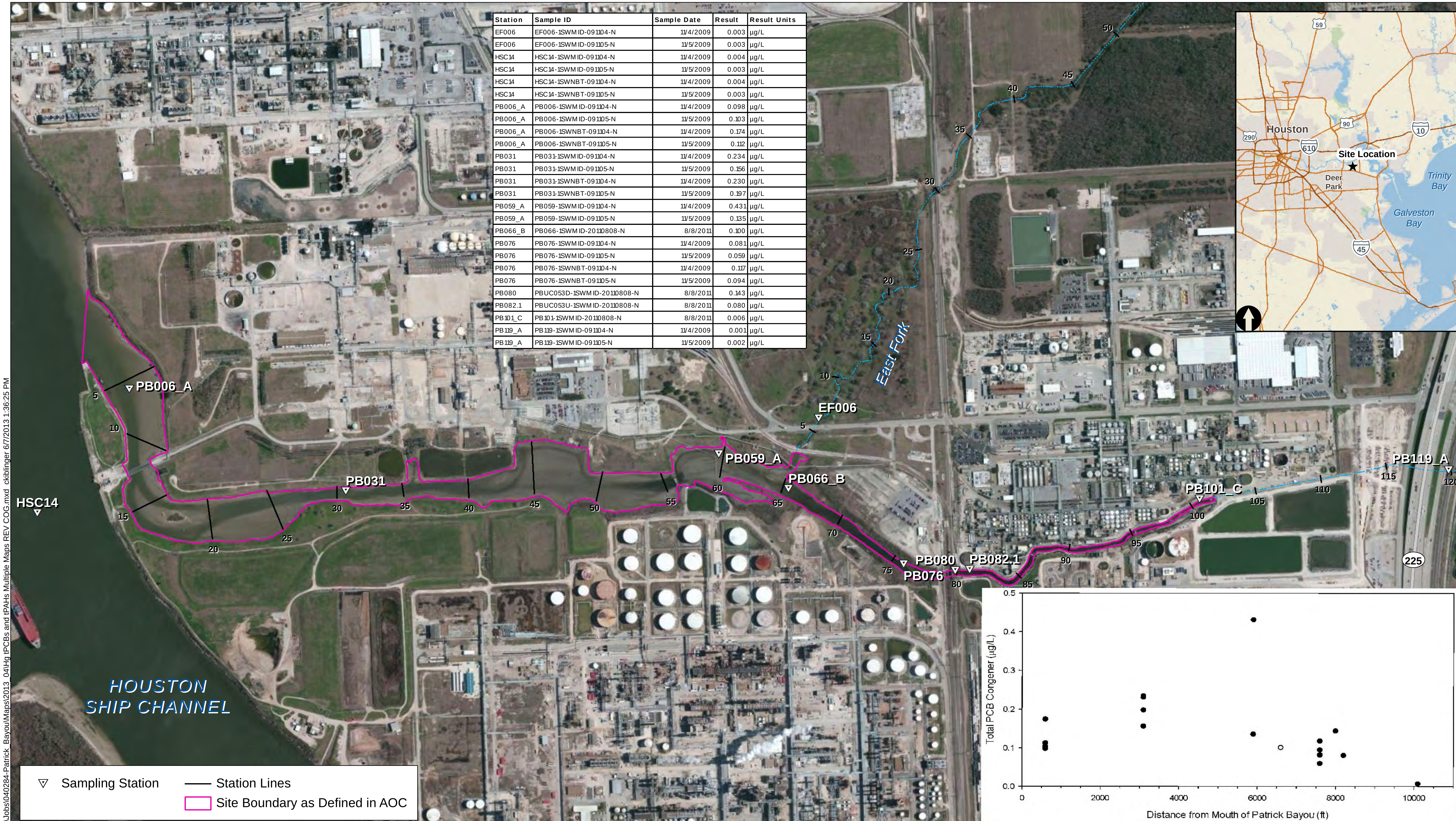


Q:\Jobs\040284-Patrick_Bayou\Maps\2013_05_RI\Bis(2-ethylhexyl)phthalate Results in Porewater Samples.mxd ckiblinger 6/7/2013 1:42:31 PM

ANCHOR QEA

NOTES:
Station numbers from Patrick Bayou PSCR indicate length along channel in hundreds of feet.
Aerial imagery: Microsoft Bing Maps, copyright 2010 (accessed 6/7/2013.)

Figure 4-12
Bis(2-ethylhexyl)phthalate Results in Porewater Samples
Patrick Bayou Remedial Investigation Report
Patrick Bayou Superfund Site Remedial Investigation, Deer Park, Texas



Station	Sample ID	Sample Date	Result	Result Units
EF006	EF006-1SWMID-091104-N	11/4/2009	0.003	µg/L
EF006	EF006-1SWMID-091105-N	11/5/2009	0.003	µg/L
HSC14	HSC14-1SWMID-091104-N	11/4/2009	0.004	µg/L
HSC14	HSC14-1SWMID-091105-N	11/5/2009	0.003	µg/L
HSC14	HSC14-1SWNBT-091104-N	11/4/2009	0.004	µg/L
HSC14	HSC14-1SWNBT-091105-N	11/5/2009	0.003	µg/L
PB006_A	PB006-1SWMID-091104-N	11/4/2009	0.098	µg/L
PB006_A	PB006-1SWMID-091105-N	11/5/2009	0.103	µg/L
PB006_A	PB006-1SWNBT-091104-N	11/4/2009	0.174	µg/L
PB006_A	PB006-1SWNBT-091105-N	11/5/2009	0.112	µg/L
PB031	PB031-1SWMID-091104-N	11/4/2009	0.234	µg/L
PB031	PB031-1SWMID-091105-N	11/5/2009	0.156	µg/L
PB031	PB031-1SWNBT-091104-N	11/4/2009	0.230	µg/L
PB031	PB031-1SWNBT-091105-N	11/5/2009	0.197	µg/L
PB059_A	PB059-1SWMID-091104-N	11/4/2009	0.431	µg/L
PB059_A	PB059-1SWMID-091105-N	11/5/2009	0.135	µg/L
PB066_B	PB066-1SWMID-20110808-N	8/8/2011	0.100	µg/L
PB076	PB076-1SWMID-091104-N	11/4/2009	0.081	µg/L
PB076	PB076-1SWMID-091105-N	11/5/2009	0.059	µg/L
PB076	PB076-1SWNBT-091104-N	11/4/2009	0.117	µg/L
PB076	PB076-1SWNBT-091105-N	11/5/2009	0.094	µg/L
PB080	PBUC053D-1SWMID-20110808-N	8/8/2011	0.143	µg/L
PB082.1	PBUC053U-1SWMID-20110808-N	8/8/2011	0.080	µg/L
PB101_C	PB101-1SWMID-20110808-N	8/8/2011	0.006	µg/L
PB119_A	PB119-1SWMID-091104-N	11/4/2009	0.001	µg/L
PB119_A	PB119-1SWMID-091105-N	11/5/2009	0.002	µg/L

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ANCHOR QEA

NOTES:
Stations are placed in 500-foot intervals. Station numbers indicate length along channel in hundreds of feet.
Aerial imagery: Microsoft Bing Maps, copyright 2010 (accessed 6/7/2013.)

Feet
0 500 1,000

Figure 4-13
Total PCB Results in Surface Water Samples
Patrick Bayou Remedial Investigation Report
Patrick Bayou Superfund Site Remedial Investigation, Deer Park, Texas

Station	Sample ID	Sample Date	Result	Result Units
EF-001	EF001-1ST-N-071022	10/22/2007	1.1	mg/kg
EF-001	EF001-1ST-N-071210	12/10/2007	0.2	mg/kg
EF-001	EF001-2ST-N	1/22/2008	0.6	mg/kg
EF-001	EF001-4ST-N	3/25/2008	0.3	mg/kg
EF-001	EF001-5ST-N	4/30/2008	0.0	mg/kg
PB077	PB077-1T-N	9/11/2007	0.5	mg/kg
PB077	PB077-2ST-N	10/22/2007	2.4	mg/kg
PB077	PB077-3ST-N	12/10/2007	3.7	mg/kg
PB077	PB077-4ST-N	1/22/2008	2.1	mg/kg
PB077	PB077-5ST-N	3/25/2008	0.2	mg/kg
PB077	PB077-6ST-N	4/30/2008	0.3	mg/kg

ANCHOR QEA

NOTES:
Stations are placed in 500-foot intervals. Station numbers indicate length along channel in hundreds of feet.
Aerial imagery: Microsoft Bing Maps, copyright 2010 (accessed 6/7/2013.)

Feet
0 500 1,000

Figure 4-14
Total PCB Results in Sediment Trap Samples
Patrick Bayou Remedial Investigation Report
Patrick Bayou Superfund Site Remedial Investigation, Deer Park, Texas

Station	Sample ID	Sample Date	Result	Result Units
EF-001	EF001-1ST-N-071022	10/22/2007	17	mg/kg
EF-001	EF001-1ST-N-071210	12/10/2007	15.9	mg/kg
EF-001	EF001-2ST-N	1/22/2008	15	mg/kg
EF-001	EF001-4ST-N	3/25/2008	0.9	mg/kg
EF-001	EF001-5ST-N	4/30/2008	8.9	mg/kg
PB077	PB077-1T-N	9/11/2007	11.5	mg/kg
PB077	PB077-2ST-N	10/22/2007	6.6	mg/kg
PB077	PB077-3ST-N	12/10/2007	7.7	mg/kg
PB077	PB077-4ST-N	1/22/2008	5.0	mg/kg
PB077	PB077-5ST-N	3/25/2008	5.8	mg/kg
PB077	PB077-6ST-N	4/30/2008	7.1	mg/kg

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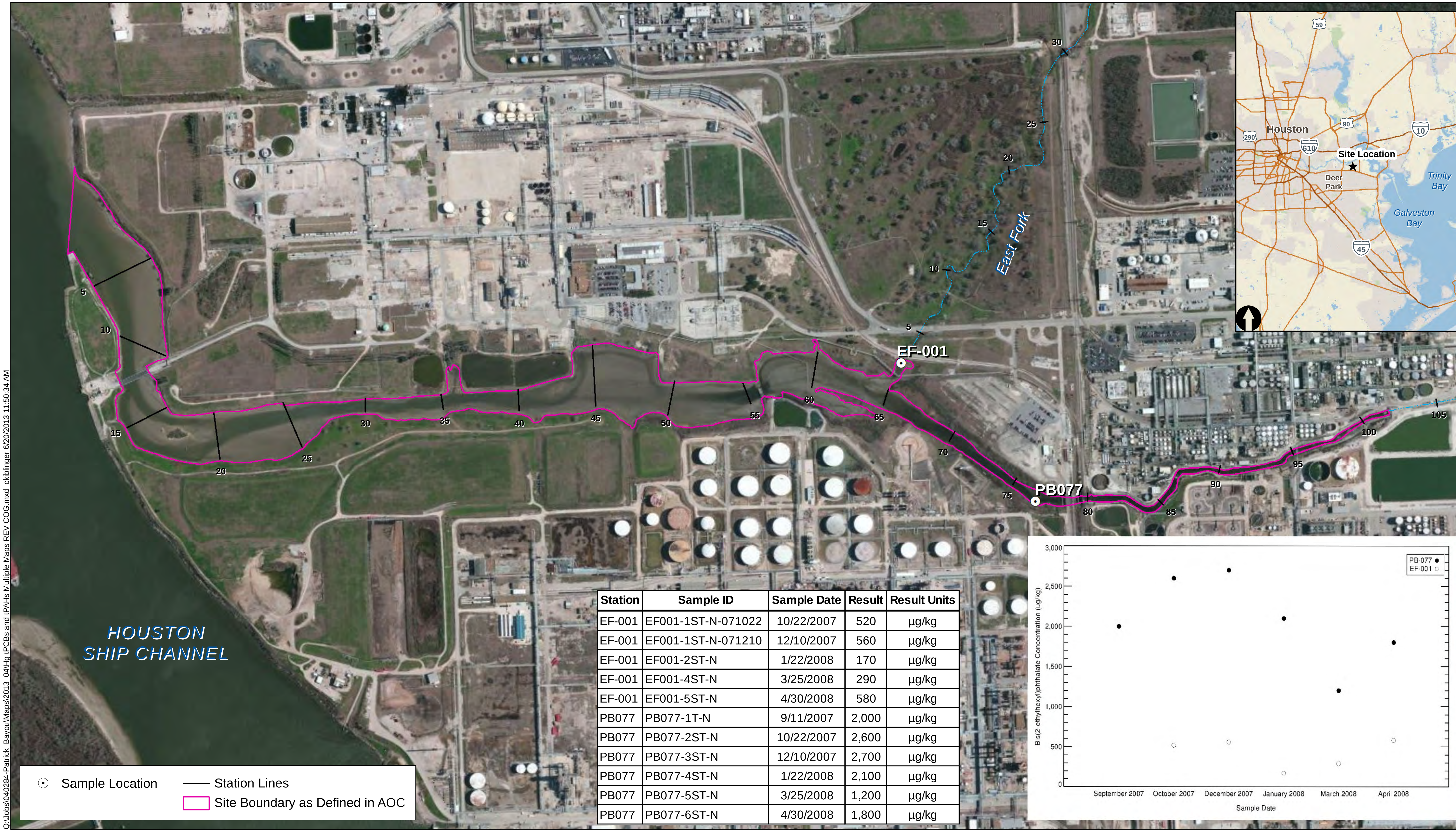
ANCHOR QEA

NOTES:
Stations are placed in 500-foot intervals. Station numbers indicate length along channel in hundreds of feet.
Aerial imagery: Microsoft Bing Maps, copyright 2010 (accessed 6/7/2013.)

Feet
0 500 1,000

Figure 4-15
Total PAH Results in Sediment Trap Samples
Patrick Bayou Remedial Investigation Report
Patrick Bayou Superfund Site Remedial Investigation, Deer Park, Texas



Station	Sample ID	Sample Date	Result	Result Units
EF-001	EF001-1ST-N-071022	10/22/2007	520	µg/kg
EF-001	EF001-1ST-N-071210	12/10/2007	560	µg/kg
EF-001	EF001-2ST-N	1/22/2008	170	µg/kg
EF-001	EF001-4ST-N	3/25/2008	290	µg/kg
EF-001	EF001-5ST-N	4/30/2008	580	µg/kg
PB077	PB077-1T-N	9/11/2007	2,000	µg/kg
PB077	PB077-2ST-N	10/22/2007	2,600	µg/kg
PB077	PB077-3ST-N	12/10/2007	2,700	µg/kg
PB077	PB077-4ST-N	1/22/2008	2,100	µg/kg
PB077	PB077-5ST-N	3/25/2008	1,200	µg/kg
PB077	PB077-6ST-N	4/30/2008	1,800	µg/kg

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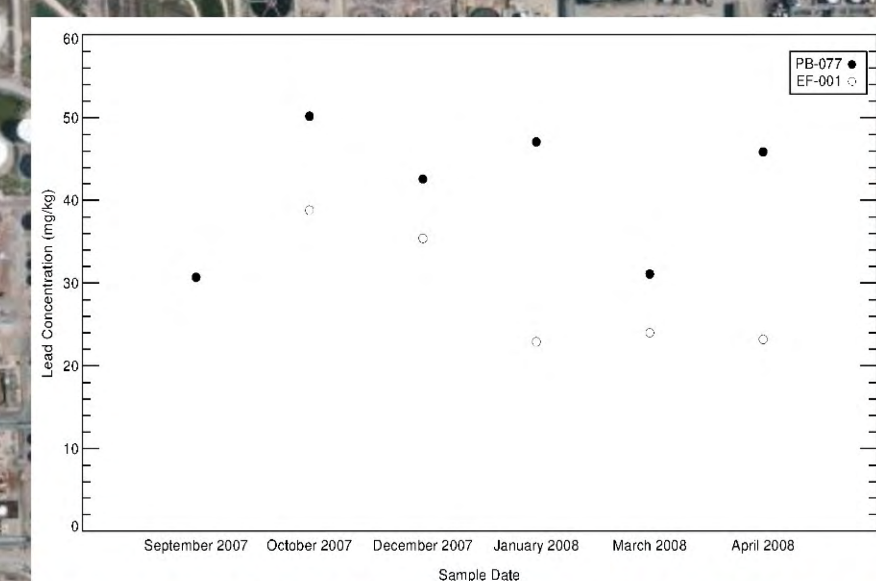
ANCHOR QEA

NOTES:
Stations are placed in 500-foot intervals. Station numbers indicate length along channel in hundreds of feet.
Aerial imagery: Microsoft Bing Maps, copyright 2010 (accessed 6/20/2013.)

Feet
0 500 1,000

Figure 4-16
Bis(2-ethylhexy)phthalate Results in Sediment Trap Samples
Patrick Bayou Remedial Investigation Report
Patrick Bayou Superfund Site Remedial Investigation, Deer Park, Texas

Station	Sample ID	Sample Date	Result	Result Units
EF-001	EF001-1ST-N-071022	10/22/2007	38.8	mg/kg
EF-001	EF001-1ST-N-071210	12/10/2007	35.4	mg/kg
EF-001	EF001-2ST-N	1/22/2008	22.9	mg/kg
EF-001	EF001-4ST-N	3/25/2008	24	mg/kg
EF-001	EF001-5ST-N	4/30/2008	23.2	mg/kg
PB077	PB077-1T-N	9/11/2007	30.7	mg/kg
PB077	PB077-2ST-N	10/22/2007	50.2	mg/kg
PB077	PB077-3ST-N	12/10/2007	42.6	mg/kg
PB077	PB077-4ST-N	1/22/2008	47.1	mg/kg
PB077	PB077-5ST-N	3/25/2008	31.1	mg/kg
PB077	PB077-6ST-N	4/30/2008	45.9	mg/kg



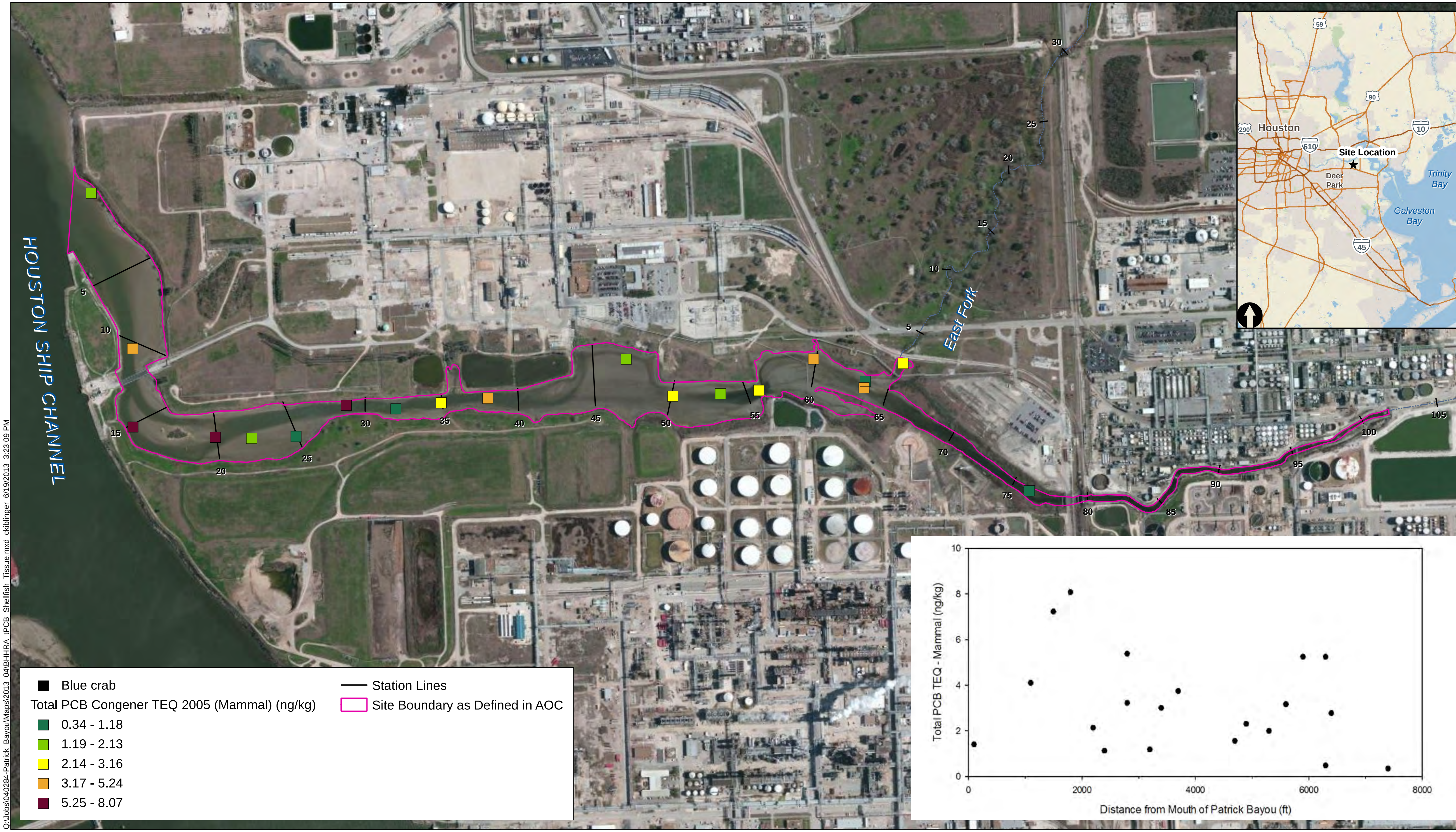
Q:\Jobs\040284-Patrick_Bayou\Maps\2013_04\Hg tPCBs and tPAHs Multiple Maps REV COG.mxd ckiblinger 6/20/2013 11:49:39 AM

ANCHOR QEA

NOTES:
Stations are placed in 500-foot intervals. Station numbers indicate length along channel in hundreds of feet.
Aerial imagery: Microsoft Bing Maps, copyright 2010 (accessed 6/20/2013.)

Feet
0 500 1,000

Figure 4-17
Lead Results in Sediment Trap Samples
Patrick Bayou Remedial Investigation Report
Patrick Bayou Superfund Site Remedial Investigation, Deer Park, Texas



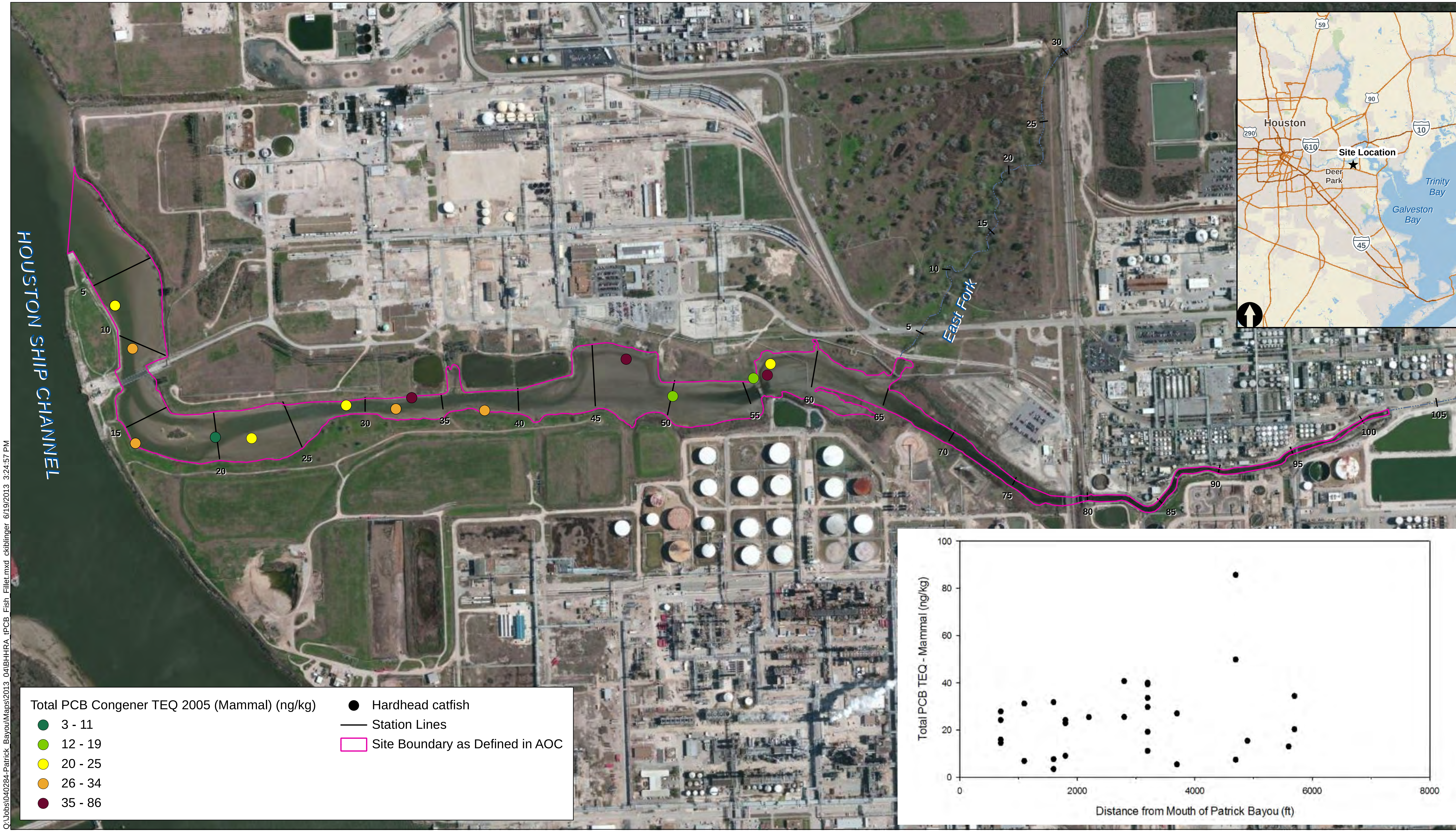
Q:\Jobs\040284-Patrick_Bayou\Maps\2013_04\BHHRA_tPCB_Shellfish_Tissue.mxd ckiblinger 6/19/2013 3:23:09 PM

ANCHOR QEA

NOTES:
Station numbers from Patrick Bayou PSCR indicate length along channel in hundreds of feet.
Aerial imagery: Microsoft Bing Maps, copyright 2010 (accessed 6/19/2013).

Feet
0 500 1,000

Figure 4-18
PCB TEQ Results in Edible Shellfish Tissue Samples
Patrick Bayou Remedial Investigation Report
Patrick Bayou Superfund Site Remedial Investigation, Deer Park, Texas



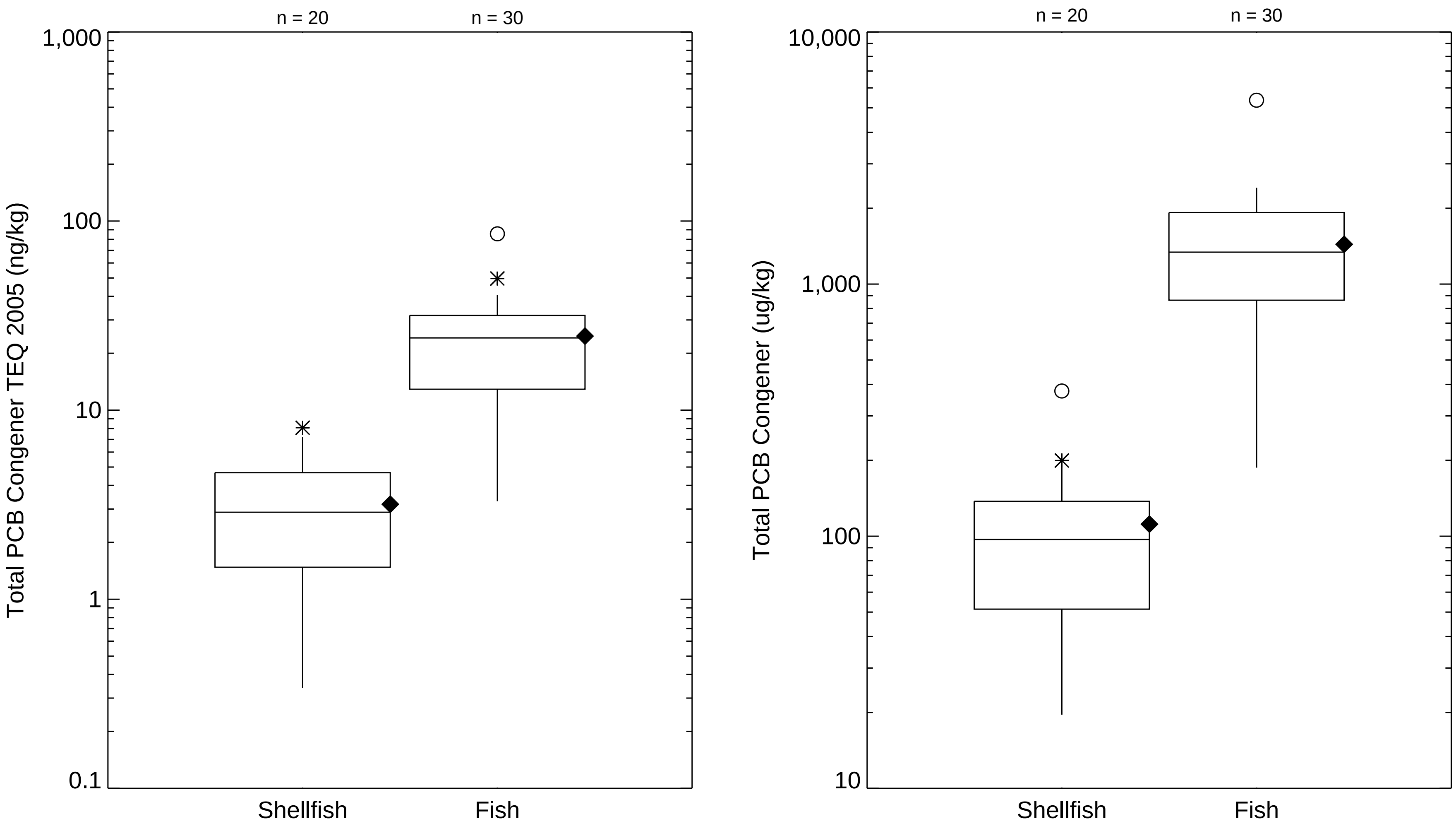
Q:\Jobs\040284-Patrick_Bayou\Maps\2013_04\BHHRA_tPCB_Fish_Fillet.mxd ckiblinger 6/19/2013 3:24:57 PM

ANCHOR QEA

NOTES:
Station numbers from Patrick Bayou PSCR indicate length along channel in hundreds of feet.
Aerial imagery: Microsoft Bing Maps, copyright 2010 (accessed 6/19/2013).

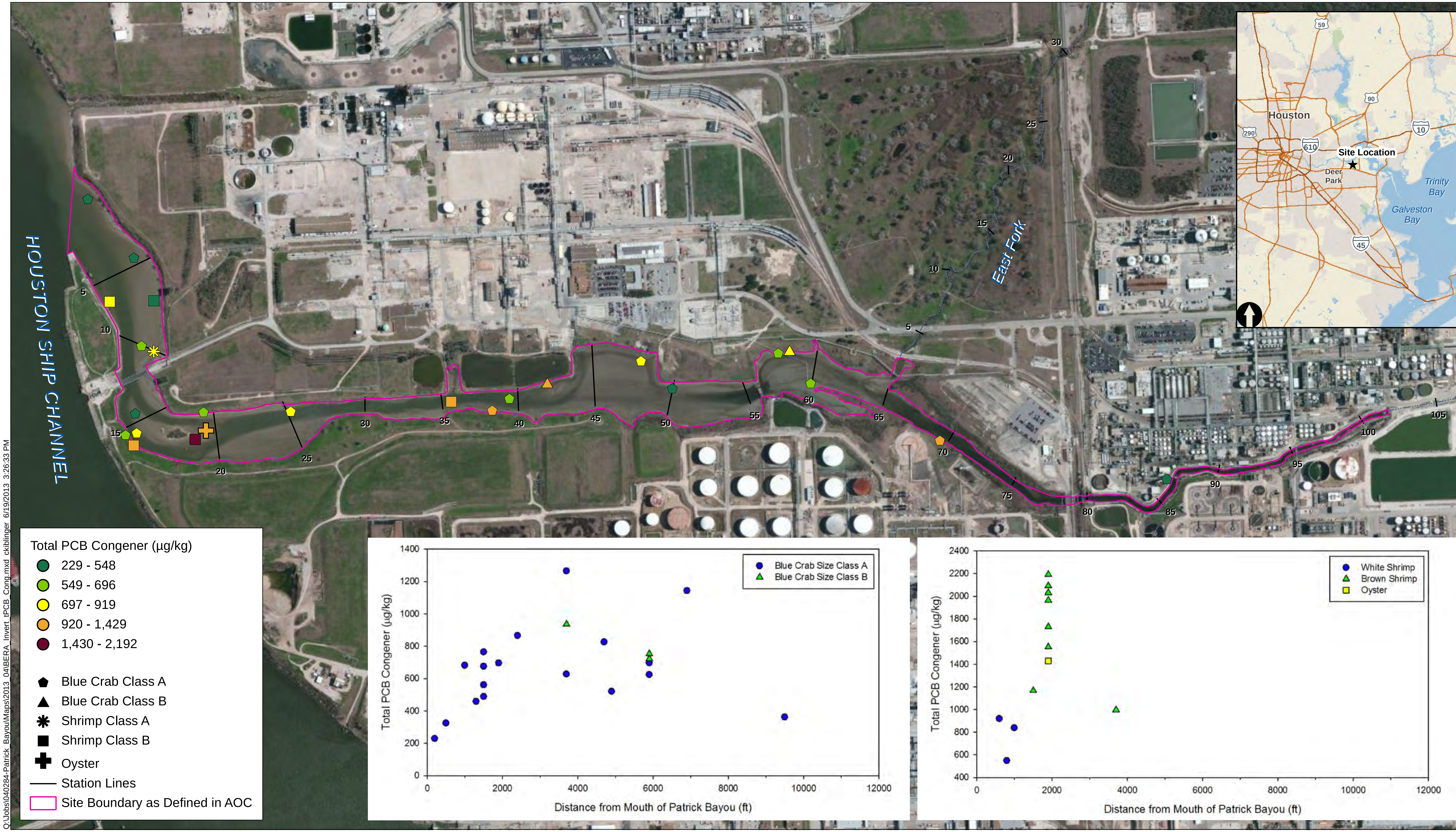
Feet
0 500 1,000

Figure 4-19
PCB TEQ Results in Fish Filet Samples
Patrick Bayou Remedial Investigation Report
Patrick Bayou Superfund Site Remedial Investigation, Deer Park, Texas



Note: Tukey box plots show the median (horizontal central line), mean (diamonds), 25th and 75th percentiles (ends of the box), whiskers (extending from the box to 1.5 times the distance between box end and the median) and inner (stars) and outer (open circles) outliers.

Figure 4-20
Total PCB and PCB TEQ in Edible Tissue Samples
Patrick Bayou Remedial Investigation Report
Patrick Bayou Superfund Site Remedial Investigation, Deer Park, Texas

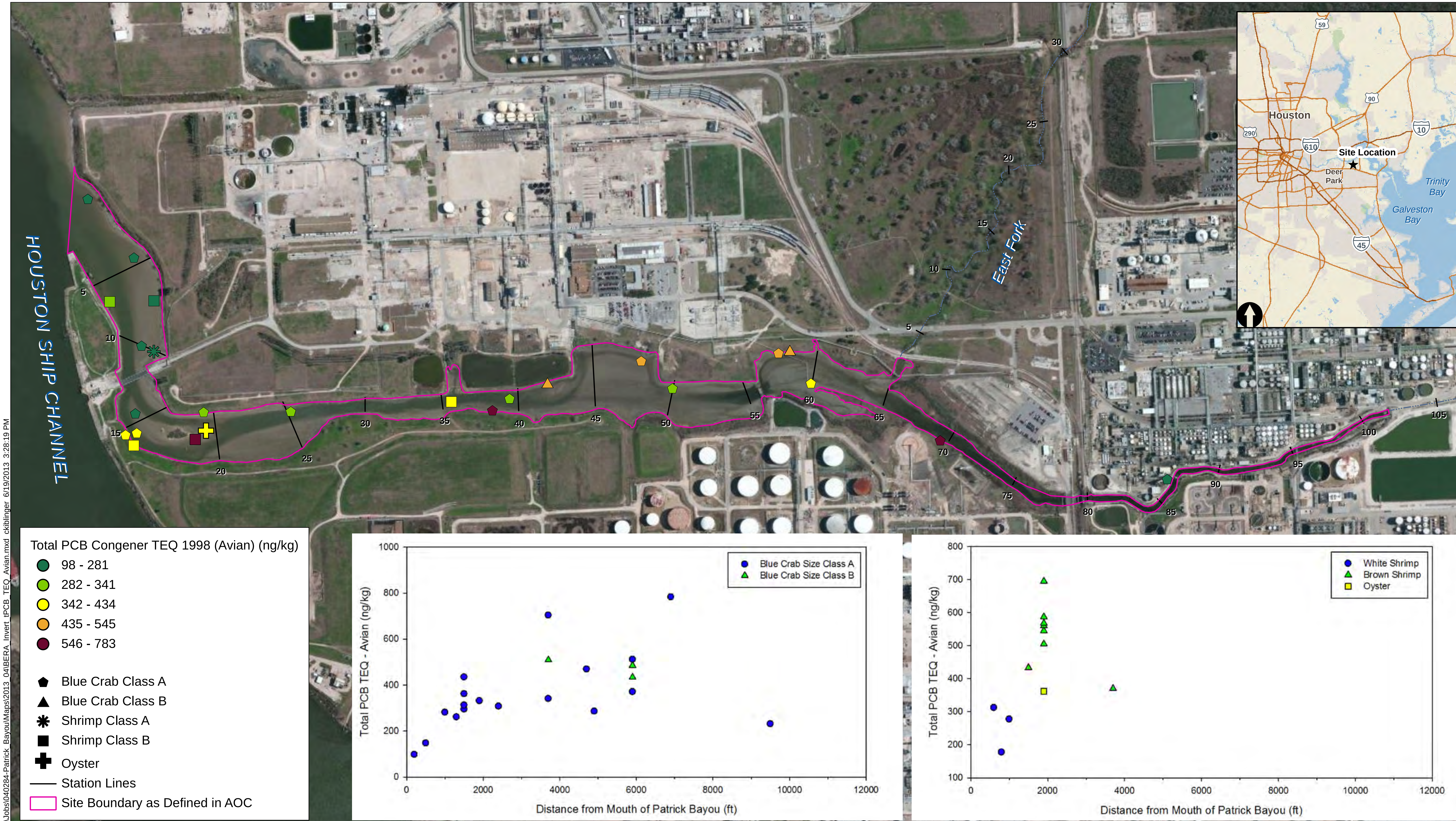


ANCHOR QEA

NOTES:
Station numbers from Patrick Bayou PSCR indicate length along channel in hundreds of feet.
Aerial imagery: Microsoft Bing Maps, copyright 2010 (accessed 6/19/2013).

Feet
0 500 1,000

Figure 4-21
Total PCB Congener Results in Whole Body Shellfish Tissue Samples
Patrick Bayou Remedial Investigation Report
Patrick Bayou Superfund Site Remedial Investigation, Deer Park, Texas



Q:\Jobs\040284-Patrick_Bayou\Maps\2013_04\BERA_Invert_tPCB_TEQ_Avian.mxd ckiblinger 6/19/2013 3:28:19 PM

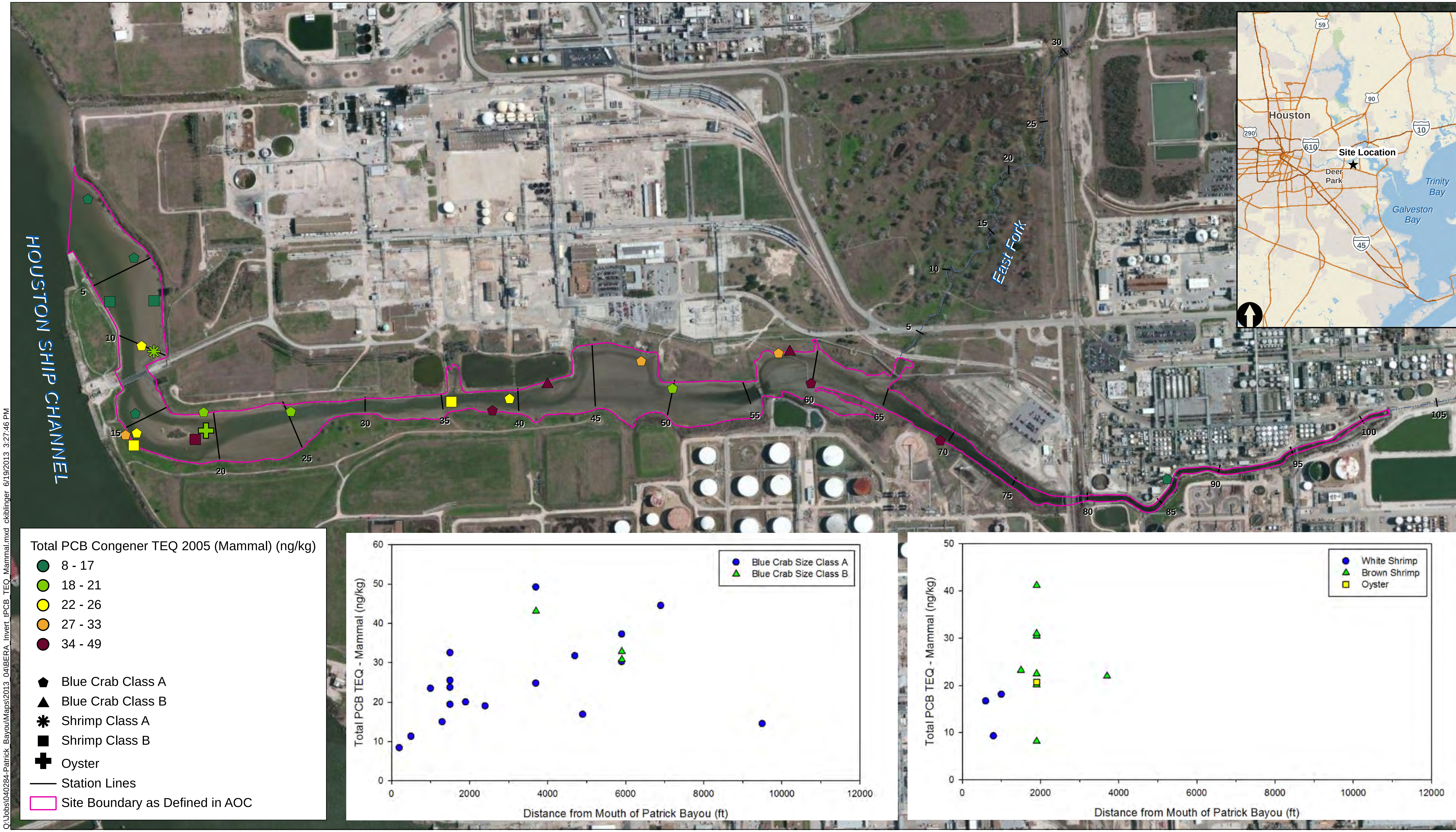
ANCHOR QEA

NOTES:
Station numbers from Patrick Bayou PSCR indicate length along channel in hundreds of feet.
Aerial imagery: Microsoft Bing Maps, copyright 2010 (accessed 6/19/2013).

Feet
0 500 1,000

Figure 4-22
PCB TEQ (avian) Results in Whole Body Shellfish Tissue Samples
Patrick Bayou Remedial Investigation Report
Patrick Bayou Superfund Site Remedial Investigation, Deer Park, Texas

Q:\Jobs\040284-Patrick_Bayou\Maps\2013_04\BERA_Invert_tPCB_TEQ_Mammal.mxd ckiblinger 6/19/2013 3:27:46 PM

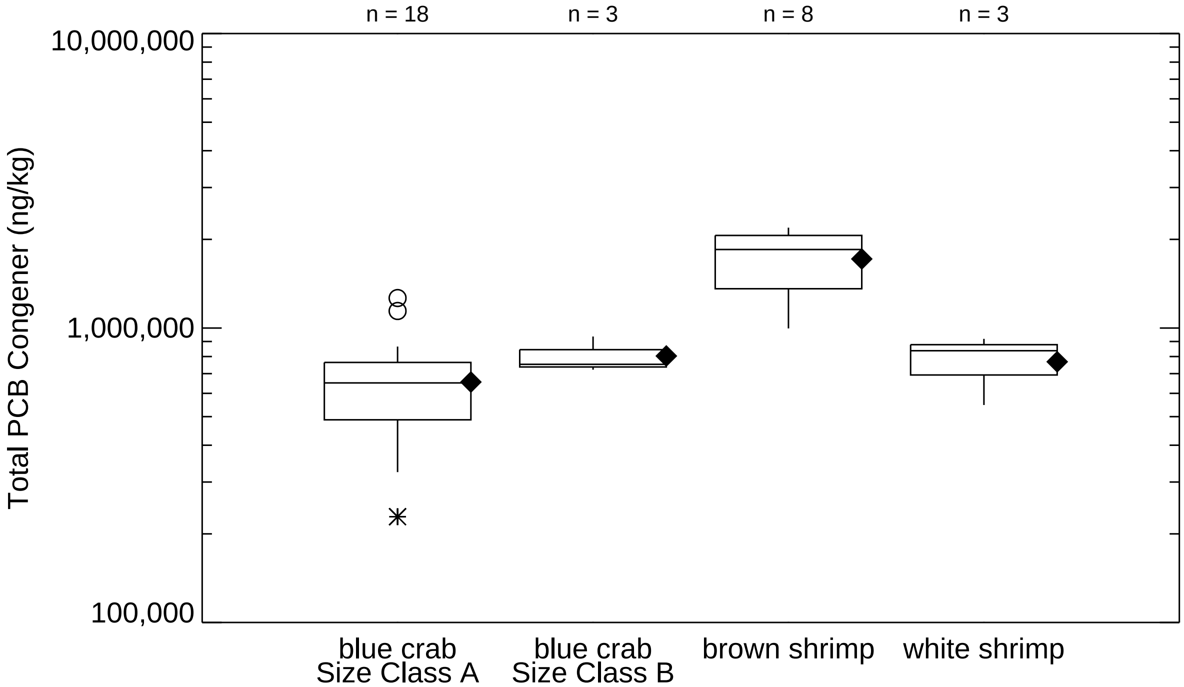


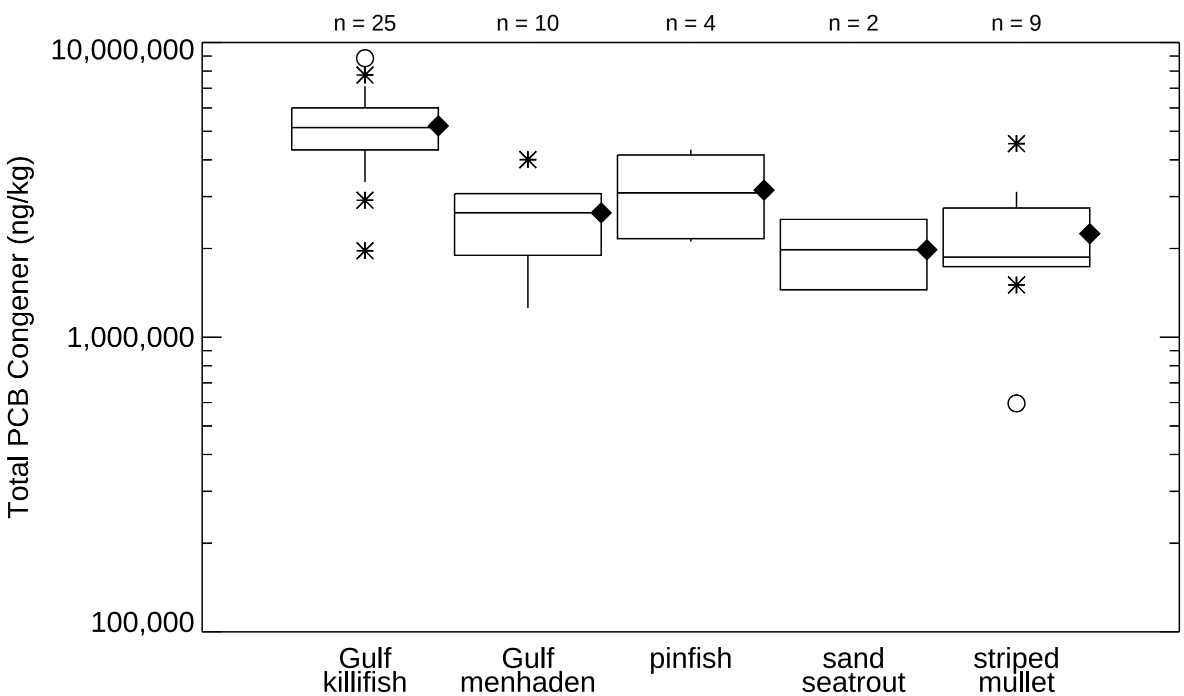
ANCHOR QEA

NOTES:
Station numbers from Patrick Bayou PSCR indicate length along channel in hundreds of feet.
Aerial imagery: Microsoft Bing Maps, copyright 2010 (accessed 6/19/2013).

Feet
0 500 1,000

Figure 4-23
PCB TEQ (mammal) Results in Whole Body Shellfish Tissue Samples
Patrick Bayou Remedial Investigation Report
Patrick Bayou Superfund Site Remedial Investigation, Deer Park, Texas

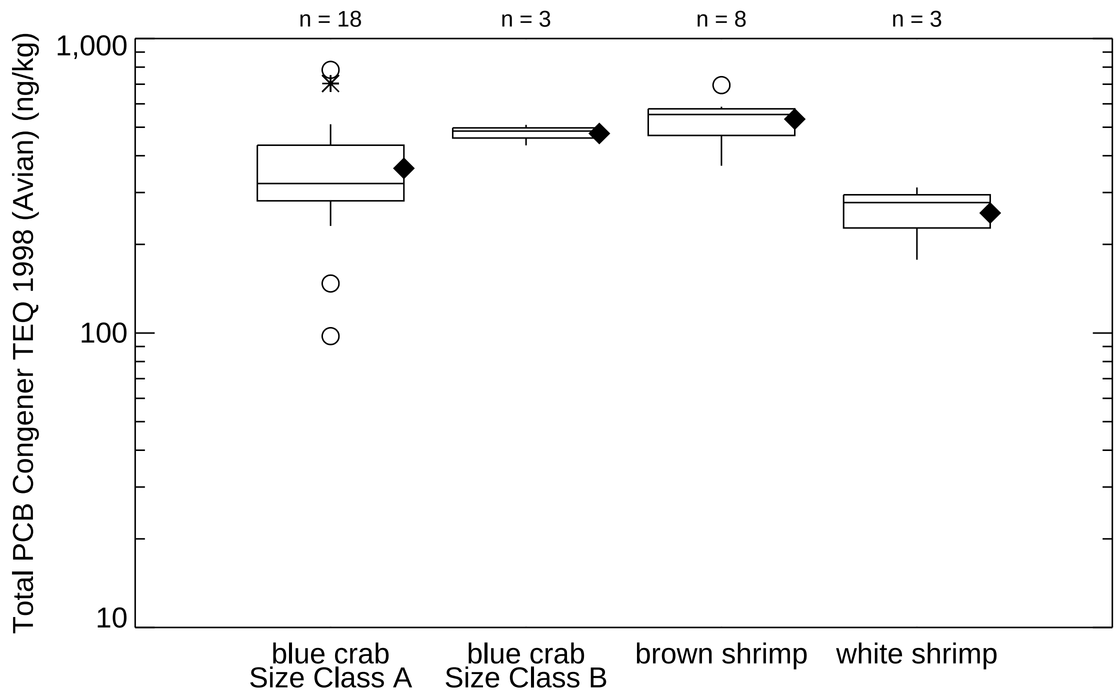


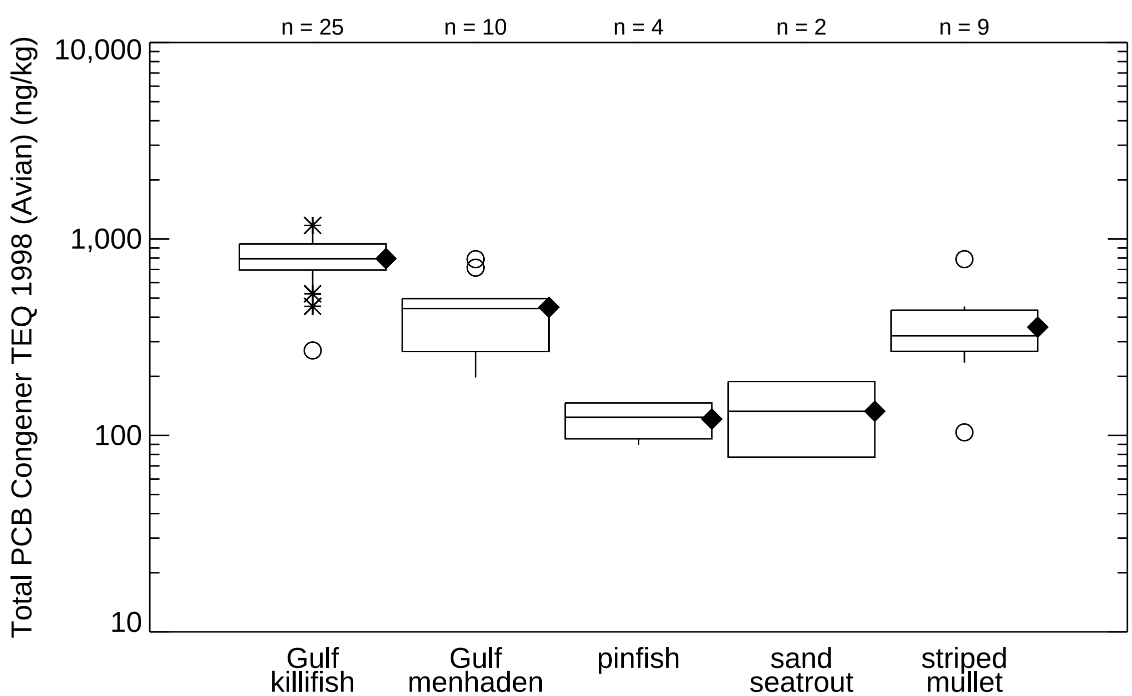


Note: Tukey box plots show the median (horizontal central line), mean (diamonds), 25th and 75th percentiles (ends of the box), whiskers (extending from the box to 1.5 times the distance between box end and the median) and inner (stars) and outer (open circles) outliers.

Figure 4-24

Box Plots of Total PCBs in Whole Body Tissue Samples
Patrick Bayou Remedial Investigation Report
Patrick Bayou Superfund Site Remedial Investigation, Deer Park, Texas



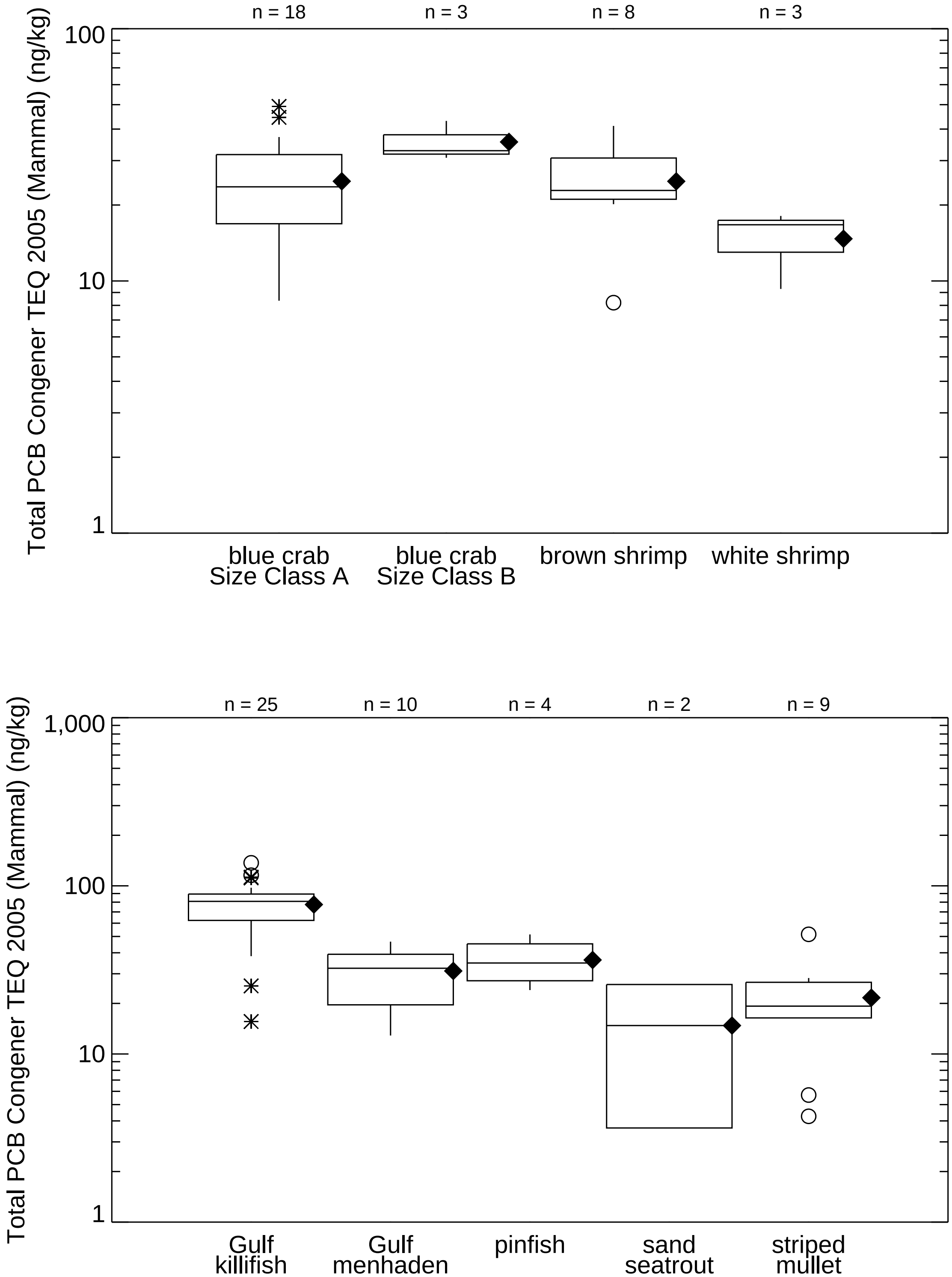


Note: Tukey box plots show the median (horizontal central line), mean (diamonds), 25th and 75th percentiles (ends of the box), whiskers (extending from the box to 1.5 times the distance between box end and the median) and inner (stars) and outer (open circles) outliers.

Figure 4-25

Box Plots of PCB TEQs (Avian) in Whole Body Tissue Samples
Patrick Bayou Remedial Investigation Report
Patrick Bayou Superfund Site Remedial Investigation, Deer Park, Texas

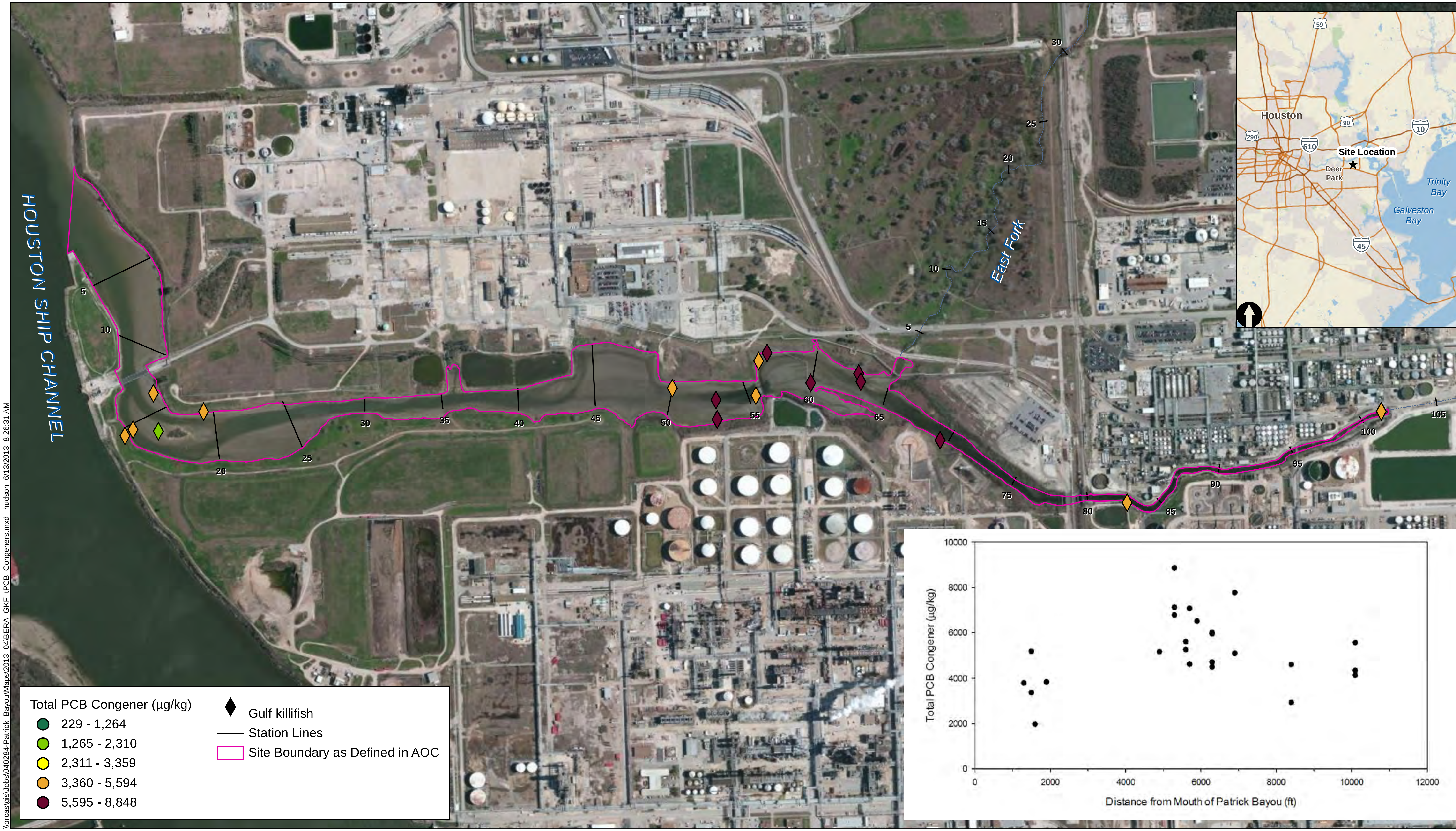
ANCHOR QEA



Note: Tukey box plots show the median (horizontal central line), mean (diamonds), 25th and 75th percentiles (ends of the box), whiskers (extending from the box to 1.5 times the distance between box end and the median) and inner (stars) and outer (open circles) outliers.

Figure 4-26

Box Plots of PCB TEQs (Mammal) in Whole Body Tissue Samples
Patrick Bayou Remedial Investigation Report
Patrick Bayou Superfund Site Remedial Investigation, Deer Park, Texas



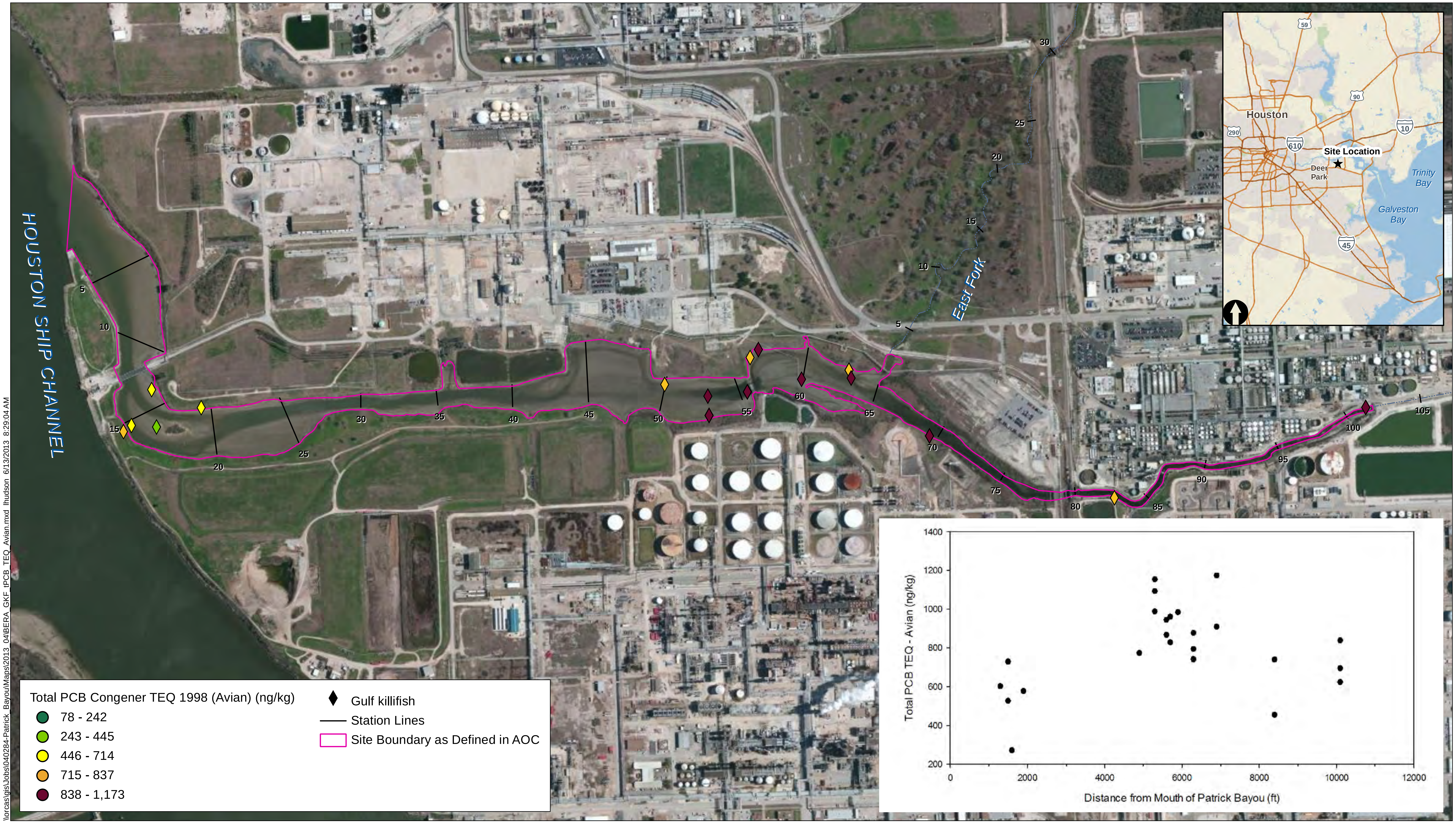
\\orcas\gis\Jobs\040284-Patrick_Bayou\Maps\2013_04\BERA_GKF_tPCB_Congeners.mxd lhudson 6/13/2013 8:26:31 AM

ANCHOR QEA

NOTES:
Station numbers from Patrick Bayou PSCR indicate length along channel in hundreds of feet.
Aerial imagery: Microsoft Bing Maps, copyright 2010 (accessed 6/13/2013).

Feet
0 500 1,000

Figure 4-27
Total PCB Congener Results in Whole Body Gulf Killifish Tissue Samples
Patrick Bayou Remedial Investigation Report
Patrick Bayou Superfund Site Remedial Investigation, Deer Park, Texas

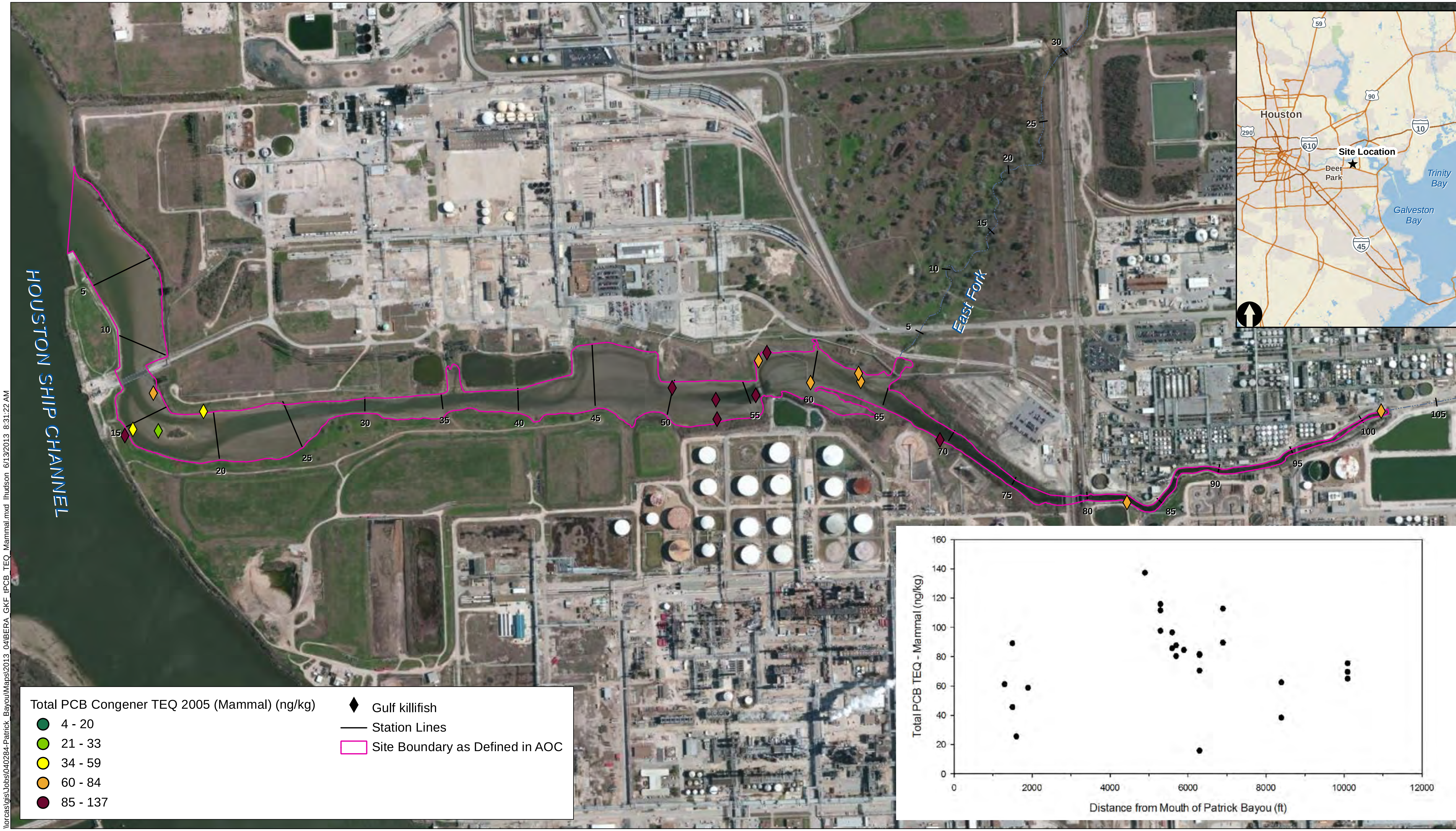


ANCHOR QEA

NOTES:
Station numbers from Patrick Bayou PSCR indicate length along channel in hundreds of feet.
Aerial imagery: Microsoft Bing Maps, copyright 2010 (accessed 6/13/2013).

Feet
0 500 1,000

Figure 4-28
PCB TEQ (avian) Results in Whole Body Gulf Killifish Tissue Samples
Patrick Bayou Remedial Investigation Report
Patrick Bayou Superfund Site Remedial Investigation, Deer Park, Texas



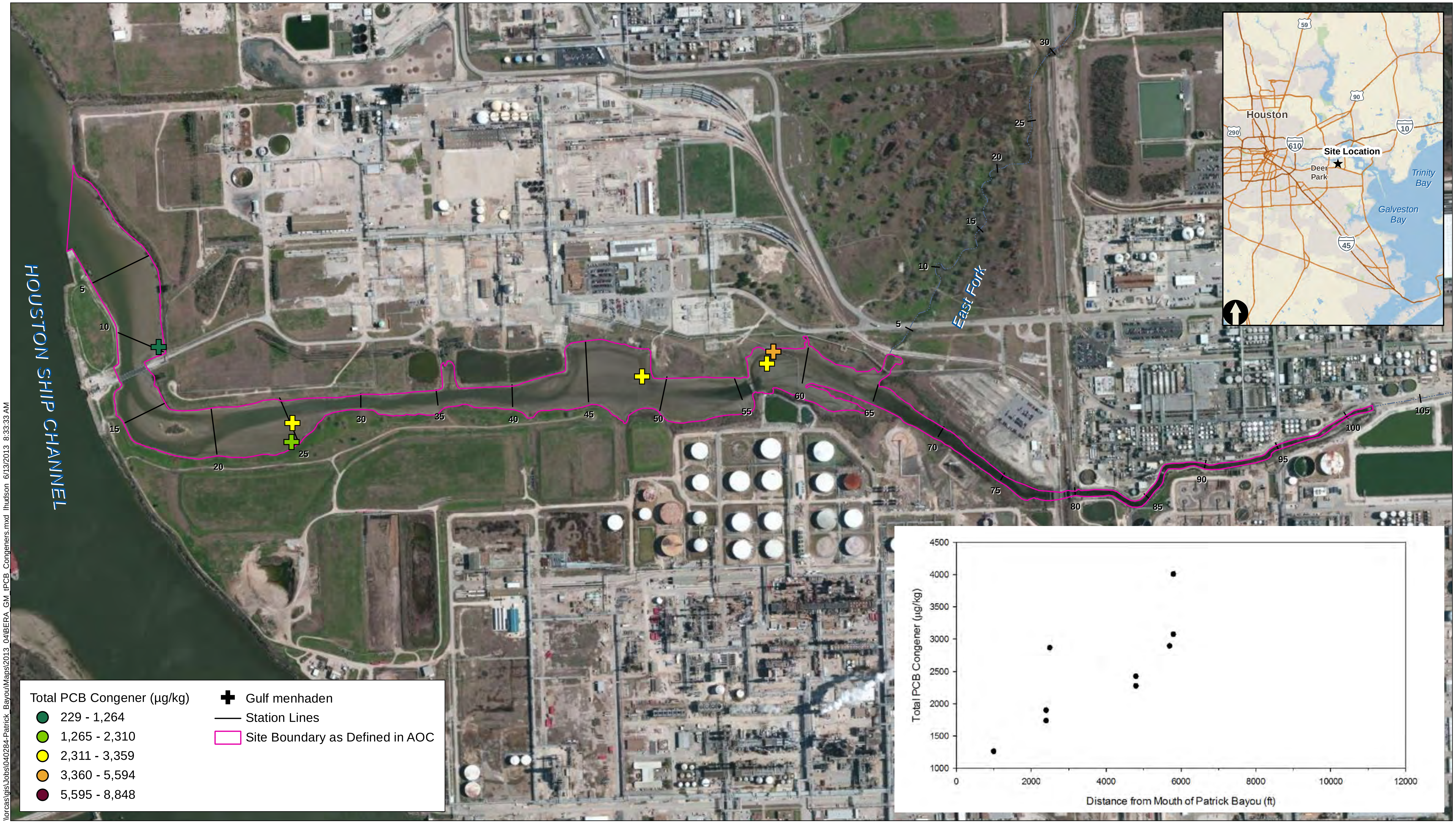
\\orcas\gis\Jobs\040284-Patrick_Bayou\Maps\2013_04\BERA_GKF_tPCB_TEQ_Mammal.mxd lhudson 6/13/2013 8:31:22 AM

ANCHOR QEA

NOTES:
Station numbers from Patrick Bayou PSCR indicate length along channel in hundreds of feet.
Aerial imagery: Microsoft Bing Maps, copyright 2010 (accessed 6/13/2013).

Feet
0 500 1,000

Figure 4-29
PCB TEQ (mammal) Results in Whole Body Gulf Killifish Tissue Samples
Patrick Bayou Remedial Investigation Report
Patrick Bayou Superfund Site Remedial Investigation, Deer Park, Texas

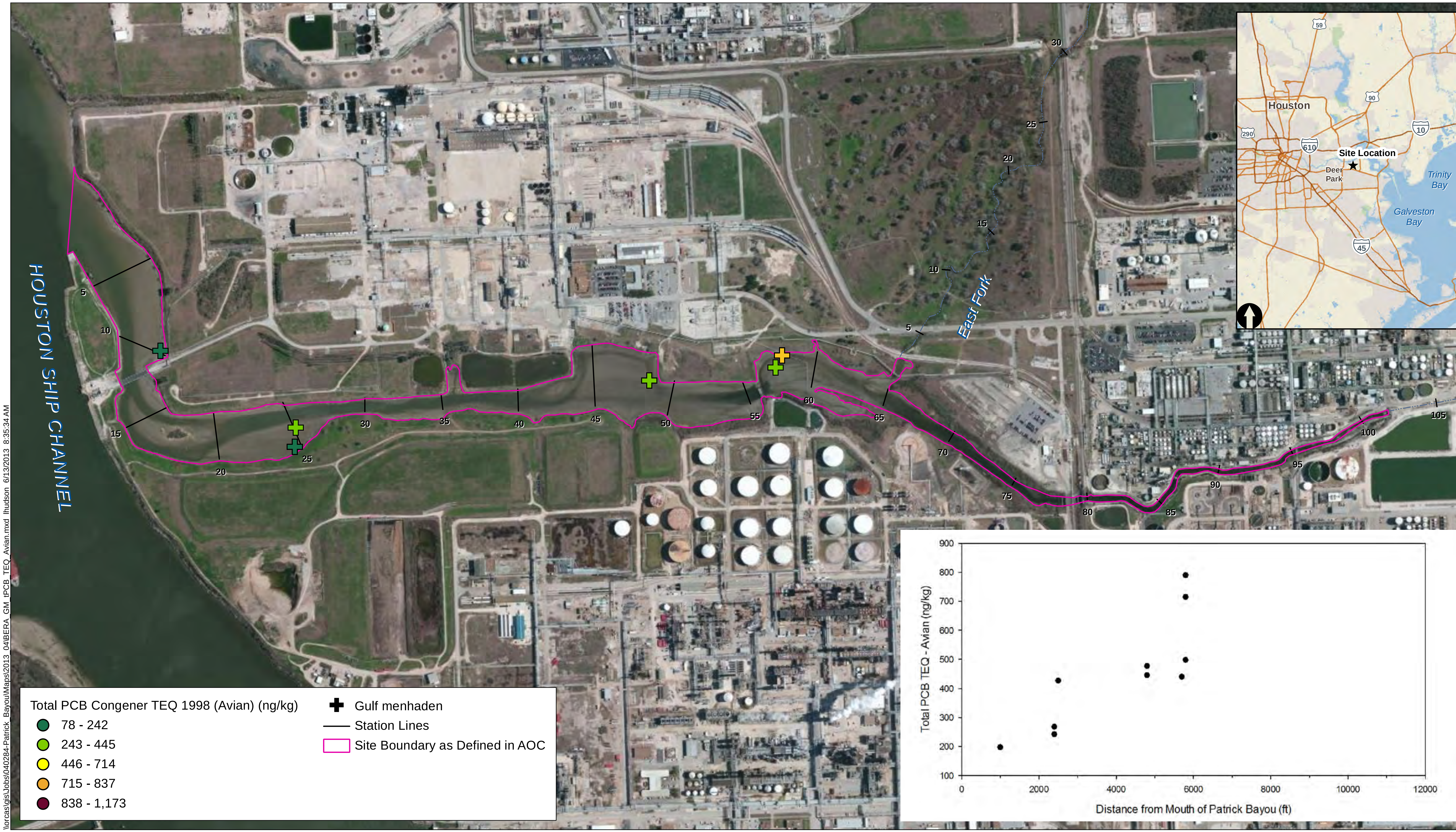


ANCHOR QEA

NOTES:
Station numbers from Patrick Bayou PSCR indicate length along channel in hundreds of feet.
Aerial imagery: Microsoft Bing Maps, copyright 2010 (accessed 6/13/2013.)

Feet
0 500 1,000

Figure 4-30
Total PCB Congener Results in Whole Body Gulf Menhaden Tissue Samples
Patrick Bayou Remedial Investigation Report
Patrick Bayou Superfund Site Remedial Investigation, Deer Park, Texas

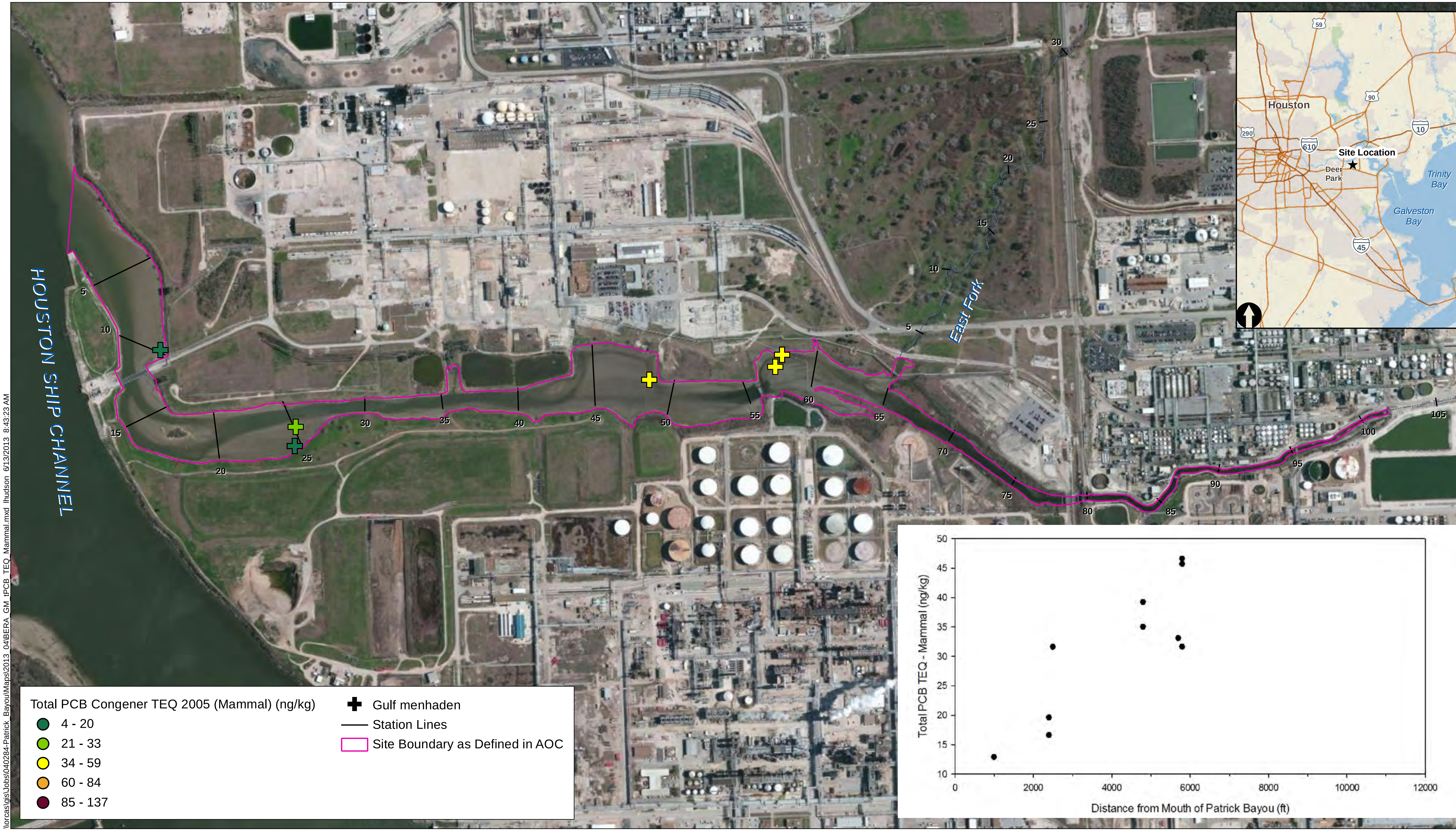


ANCHOR QEA

NOTES:
Station numbers from Patrick Bayou PSCR indicate length along channel in hundreds of feet.
Aerial imagery: Microsoft Bing Maps, copyright 2010 (accessed 6/13/2013.)

Feet
0 500 1,000

Figure 4-31
PCB TEQ (avian) Results in Whole Body Gulf Menhaden Tissue Samples
Patrick Bayou Remedial Investigation Report
Patrick Bayou Superfund Site Remedial Investigation, Deer Park, Texas

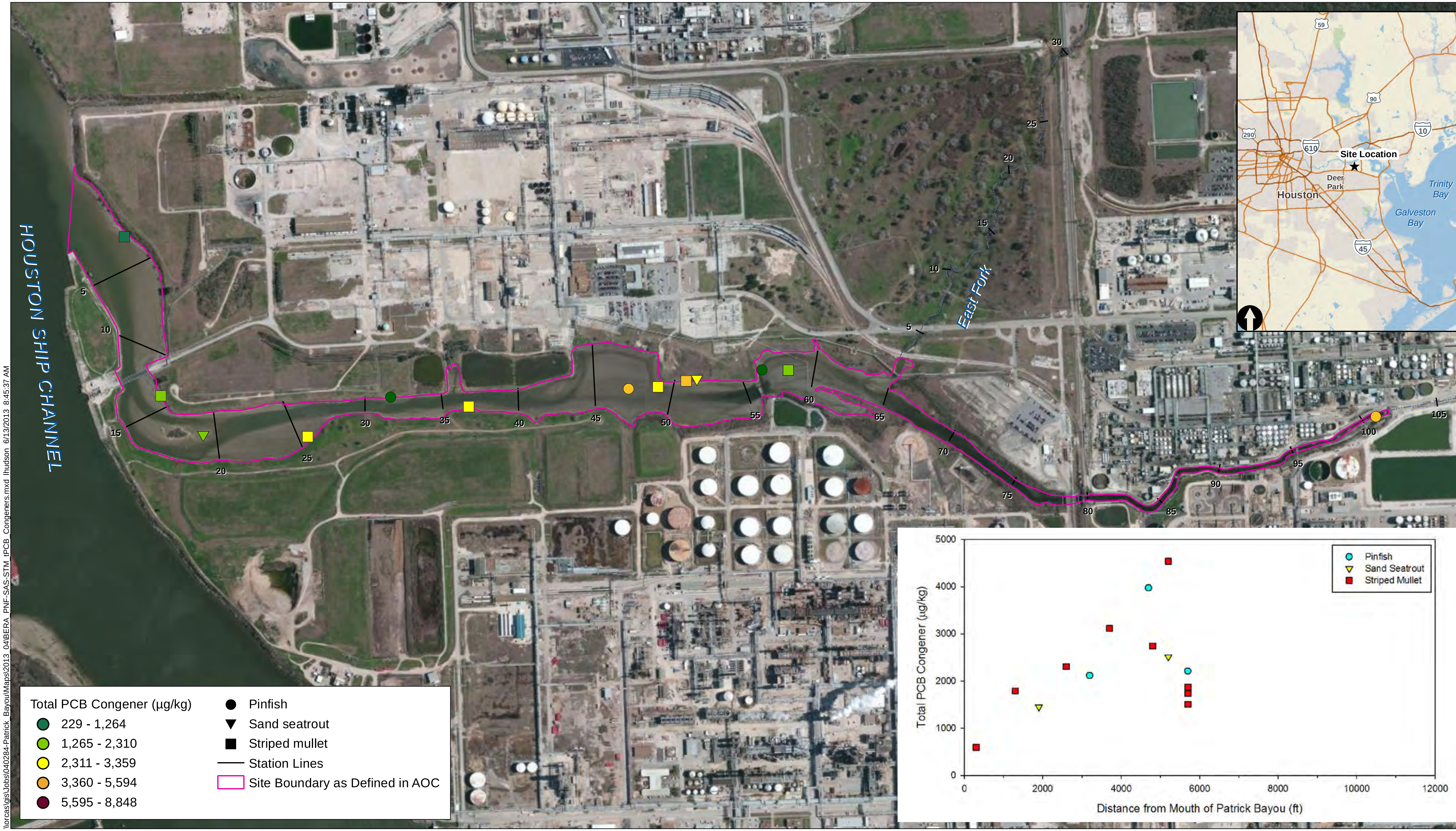


ANCHOR QEA

NOTES:
Station numbers from Patrick Bayou PSCR indicate length along channel in hundreds of feet.
Aerial imagery: Microsoft Bing Maps, copyright 2010 (accessed 6/13/2013.)

Feet
0 500 1,000

Figure 4-32
PCB TEQ (mammal) Results in Whole Body Gulf Menhaden Tissue Samples
Patrick Bayou Remedial Investigation Report
Patrick Bayou Superfund Site Remedial Investigation, Deer Park, Texas



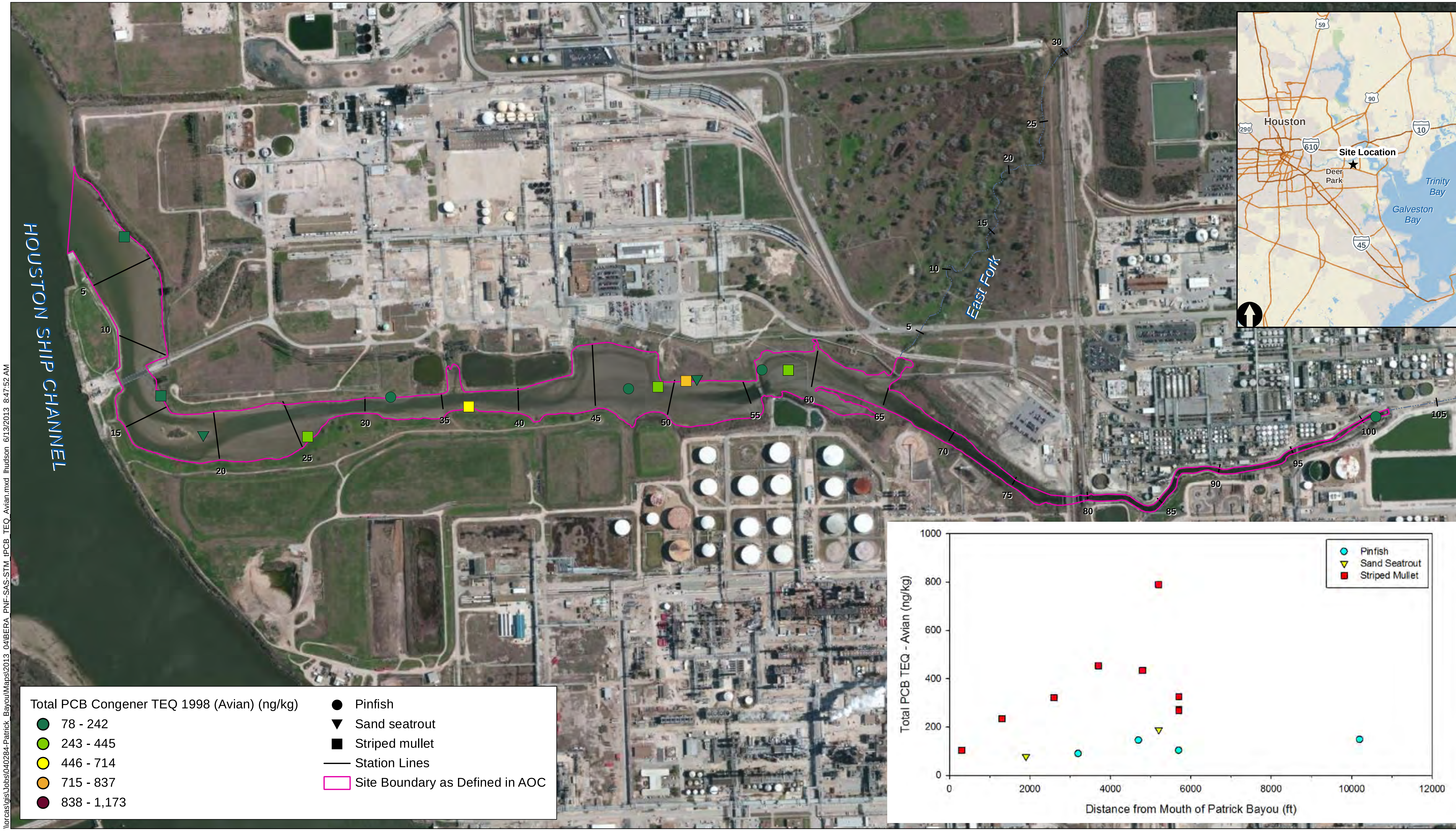
\\orcas\gis\Jobs\040284-Patrick_Bayou\Maps\2013_04\BERA_PNF-SAS-STM_tPCB_Congeners.mxd lhudson 6/13/2013 8:45:37 AM

ANCHOR QEA

NOTES:
Station numbers from Patrick Bayou PSCR indicate length along channel in hundreds of feet.
Aerial imagery: Microsoft Bing Maps, copyright 2010 (accessed 6/13/2013).

Feet
0 500 1,000

Figure 4-33
Total PCB Congener Results in Whole Body Pinfish, Sand Seatrout, and Striped Mullet Tissue Samples
Patrick Bayou Remedial Investigation Report
Patrick Bayou Superfund Site Remedial Investigation, Deer Park, Texas

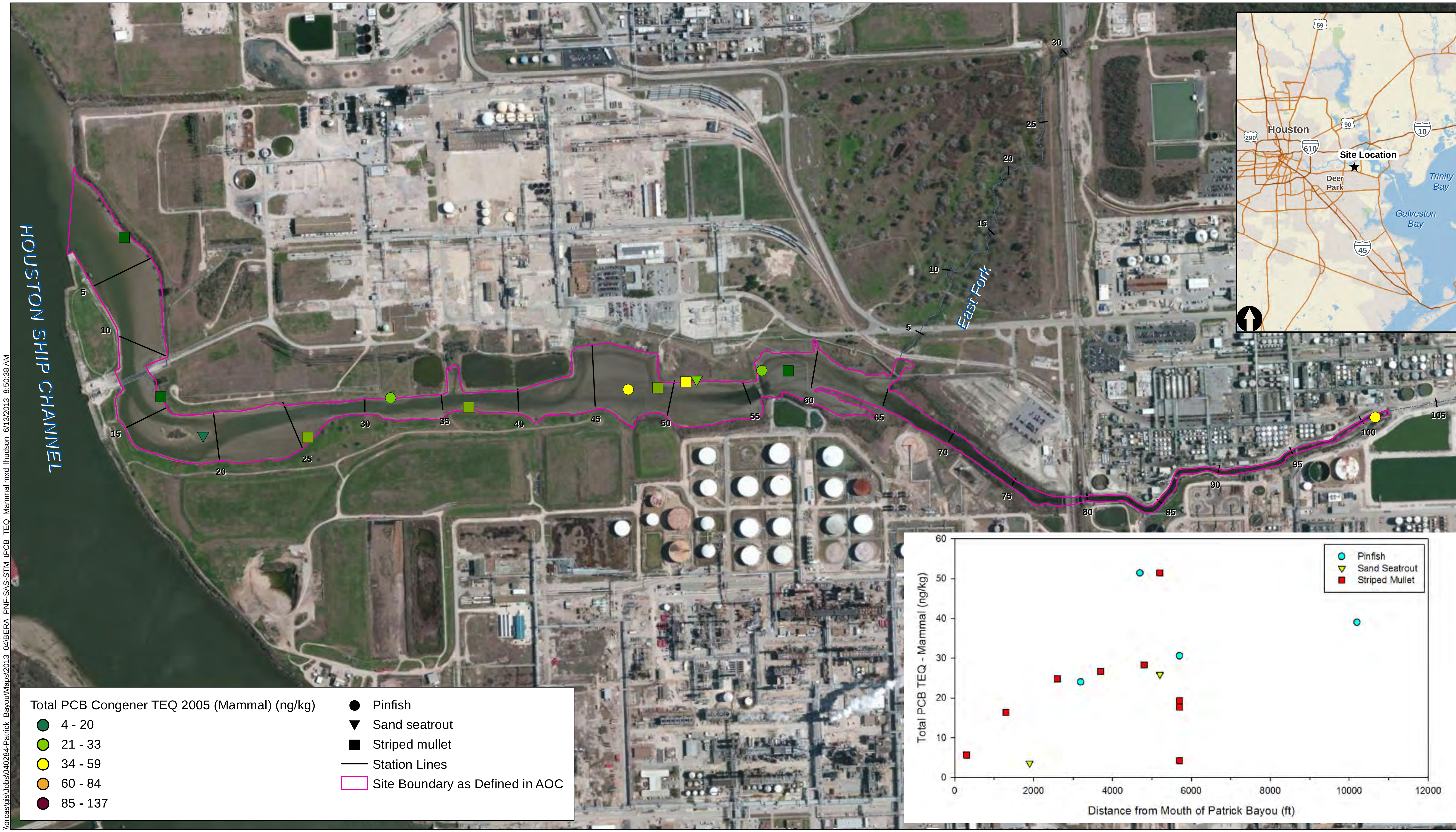


ANCHOR QEA

NOTES:
Station numbers from Patrick Bayou PSCR indicate length along channel in hundreds of feet.
Aerial imagery: Microsoft Bing Maps, copyright 2010 (accessed 6/13/2013).

Feet
0 500 1,000

Figure 4-34
Map of PCB TEQ (avian) Results in Whole Body Pinfish, Sand Seatrout, and Striped Mullet Tissue Samples
Patrick Bayou Remedial Investigation Report
Patrick Bayou Superfund Site Remedial Investigation, Deer Park, Texas

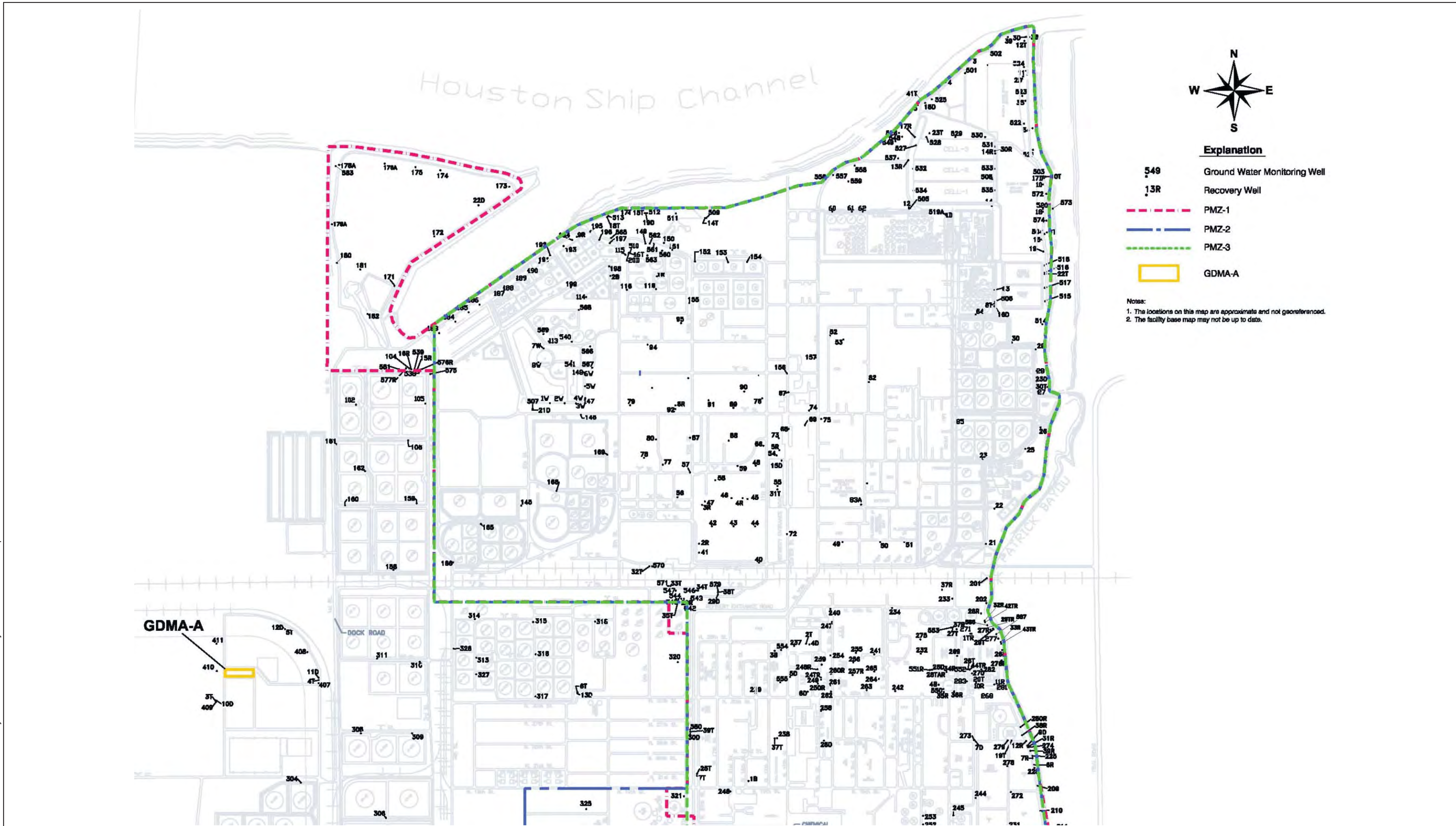


ANCHOR QEA

NOTES:
Station numbers from Patrick Bayou PSCR indicate length along channel in hundreds of feet.
Aerial imagery: Microsoft Bing Maps, copyright 2010 (accessed 6/13/2013).

Feet
0 500 1,000

Figure 4-35
PCB TEQ (mammal) Results in Whole Body Pinfish, Sand Seatrout, and Striped Mullet Tissue Samples
Patrick Bayou Remedial Investigation Report
Patrick Bayou Superfund Site Remedial Investigation, Deer Park, Texas



5/28/2013 heriksen K:\Projects\0284-Patrick Bayou Joint Defense Group\0284-RP-001.cdr

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Figure 4-36
Shell Deer Park Recovery Wells
Patrick Bayou Remedial Investigation Report
Patrick Bayou Superfund Site Remedial Investigation, Deer Park, Texas

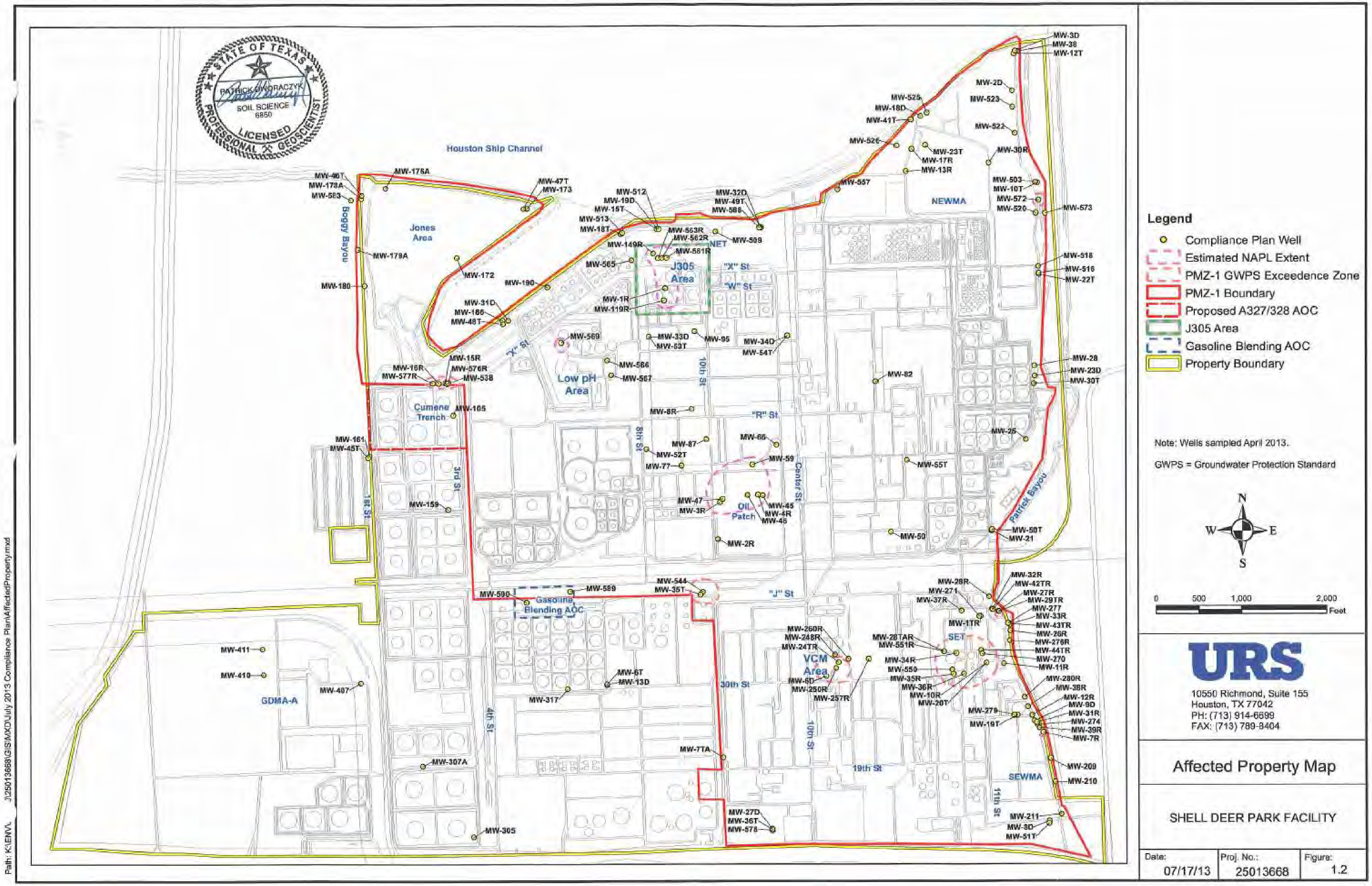
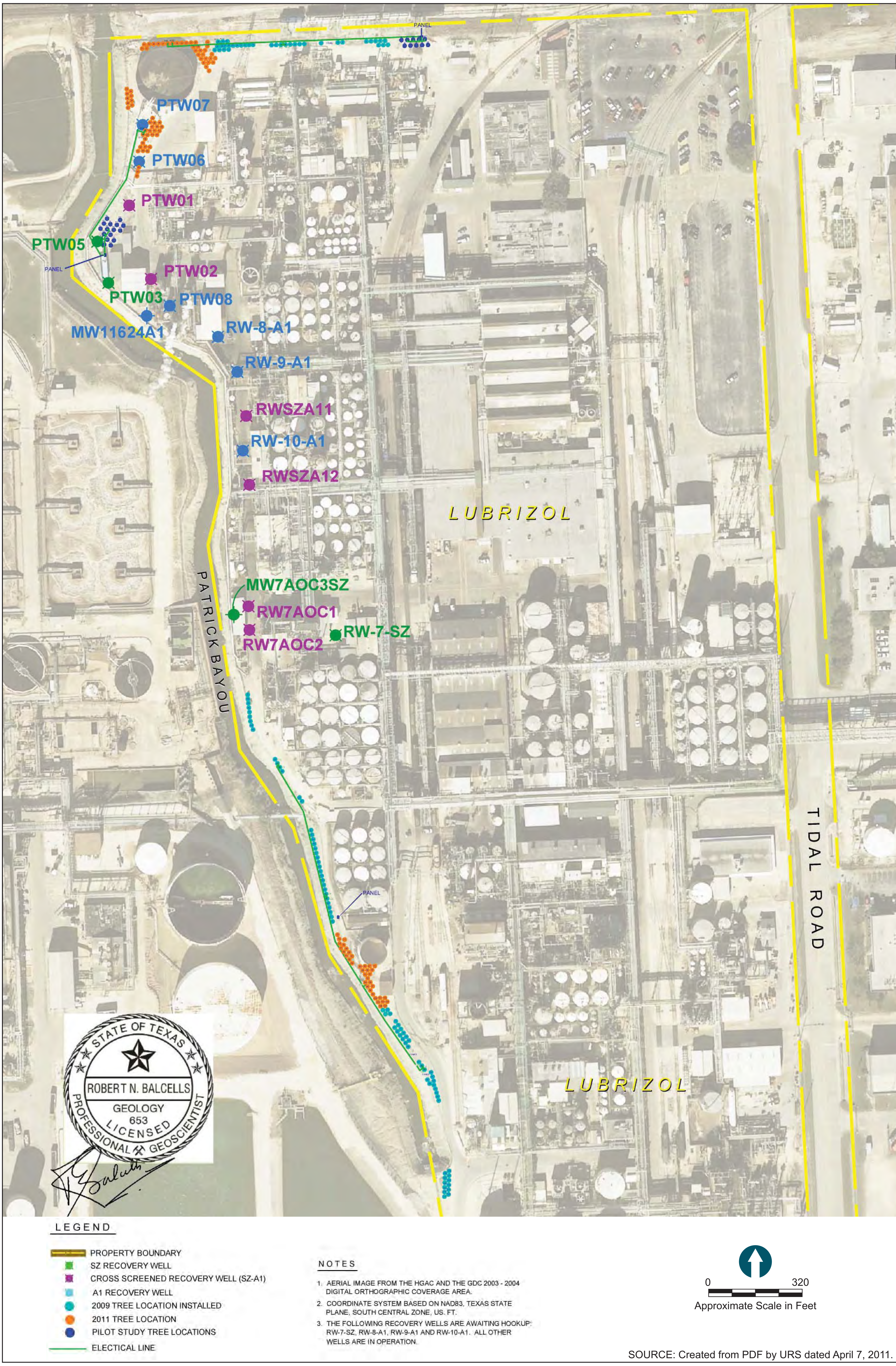


Figure 4-37
Shell Deer Park Contaminated Water Bearing Zones
Patrick Bayou Remedial Investigation Report
Patrick Bayou Superfund Site Remedial Investigation, Deer Park, Texas



5/28/2013 heriksen K:\Projects\0284-Patrick Bayou Joint Defense Group\0284-RP-001.cdr

Figure 4-38
Lubrizol Groundwater Monitoring Wells
Patrick Bayou Remedial Investigation Report
Patrick Bayou Superfund Site Remedial Investigation, Deer Park, Texas

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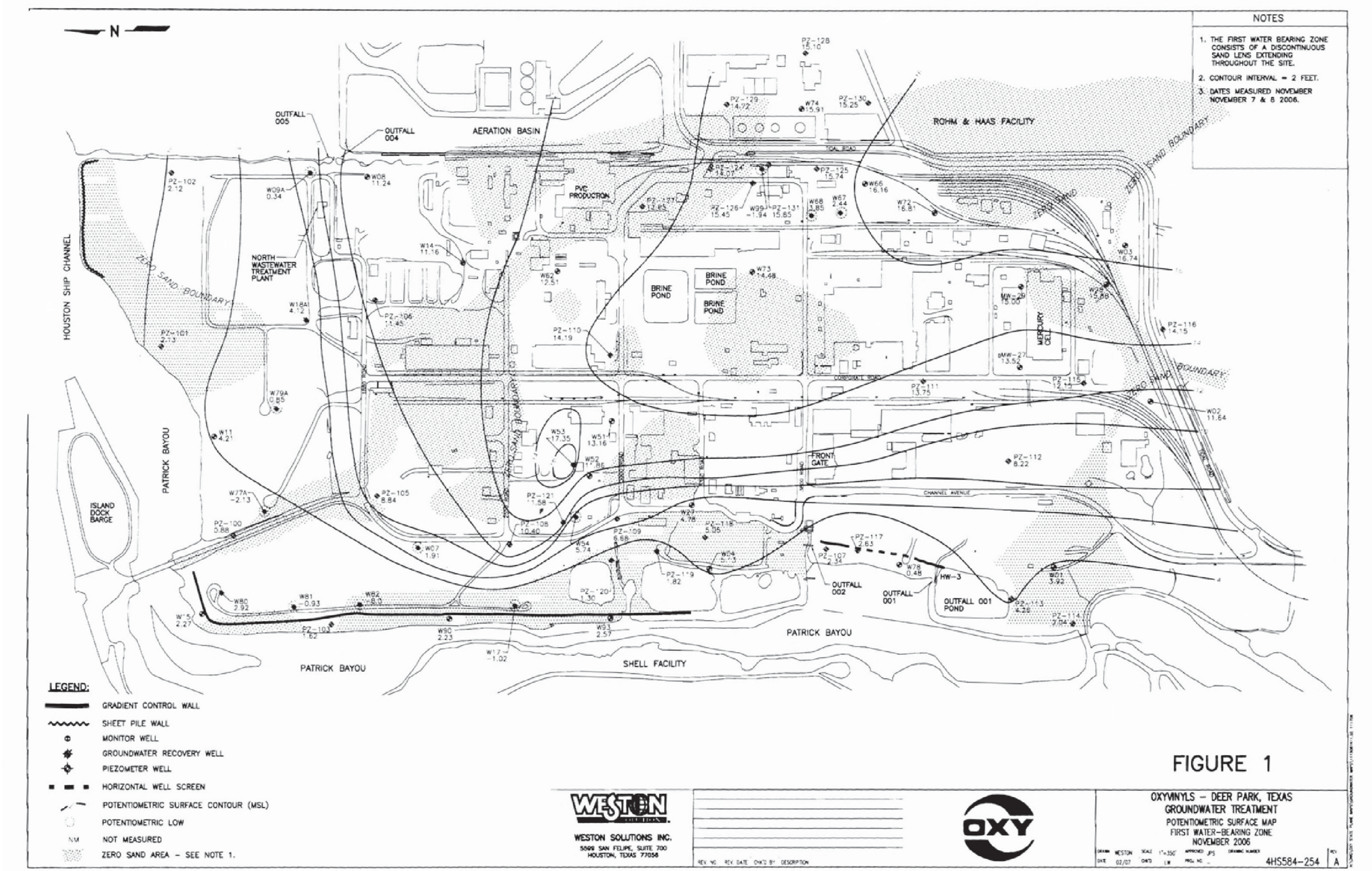

SOURCE: Created from PDF by OXY dated November 2006.

5/28/2013 heriksen K:\Projects\0284-Patrick Bayou Joint Defense Group\0284-RP-001.cdr

Figure 4-39
OxyVinyls Deer Park Recovery Wells
Patrick Bayou Remedial Investigation Report
Patrick Bayou Superfund Site Remedial Investigation, Deer Park, Texas

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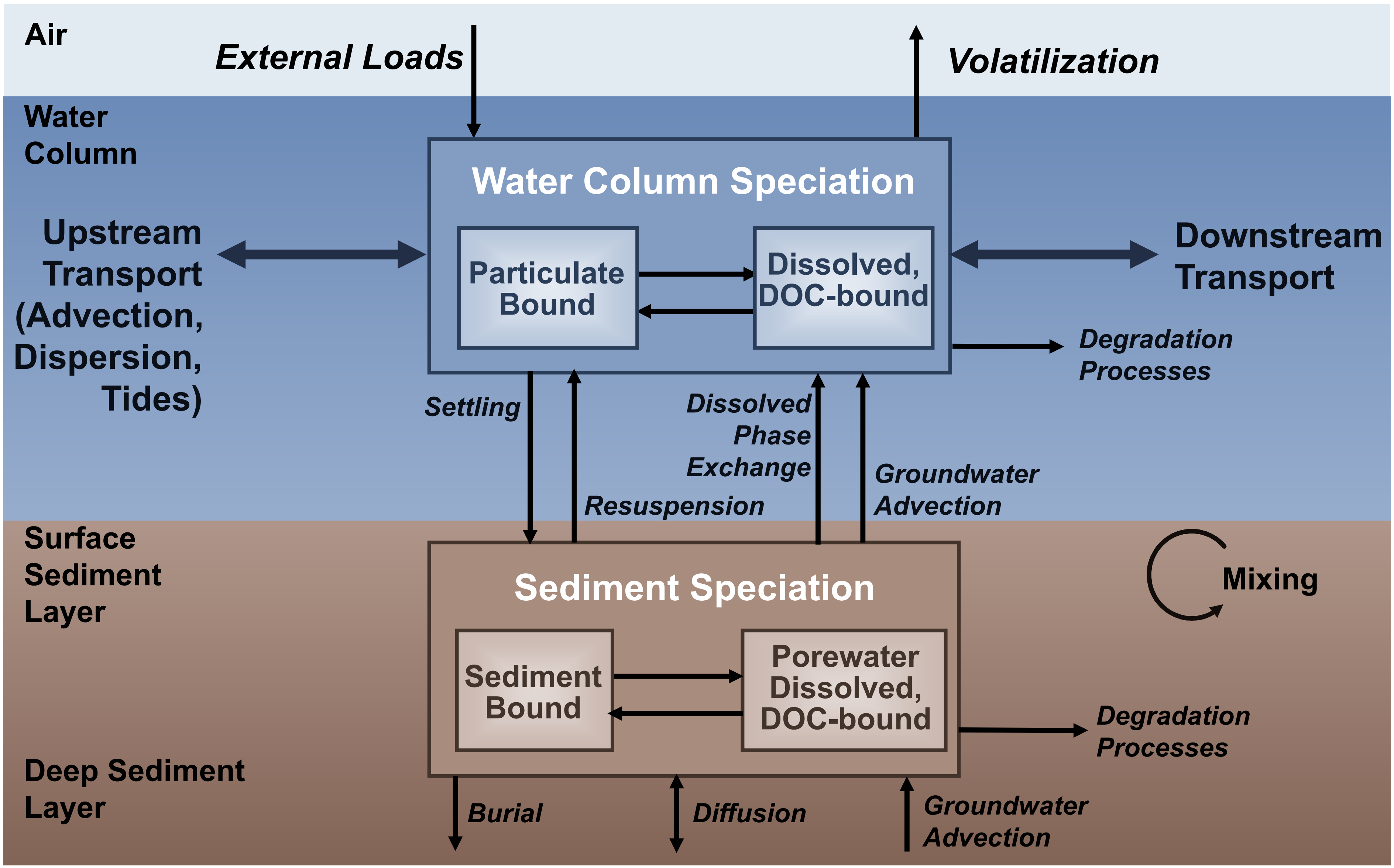
NOTES:
1. OxyVinyls outfall 001 was closed in 2010.
2. Stations are placed in 500-foot intervals. Station numbers indicate length along channel in hundreds of feet.
3. Aerial imagery: Microsoft Bing Maps, copyright 2010 (accessed 9/6/2013.)

Feet
0 500 1,000

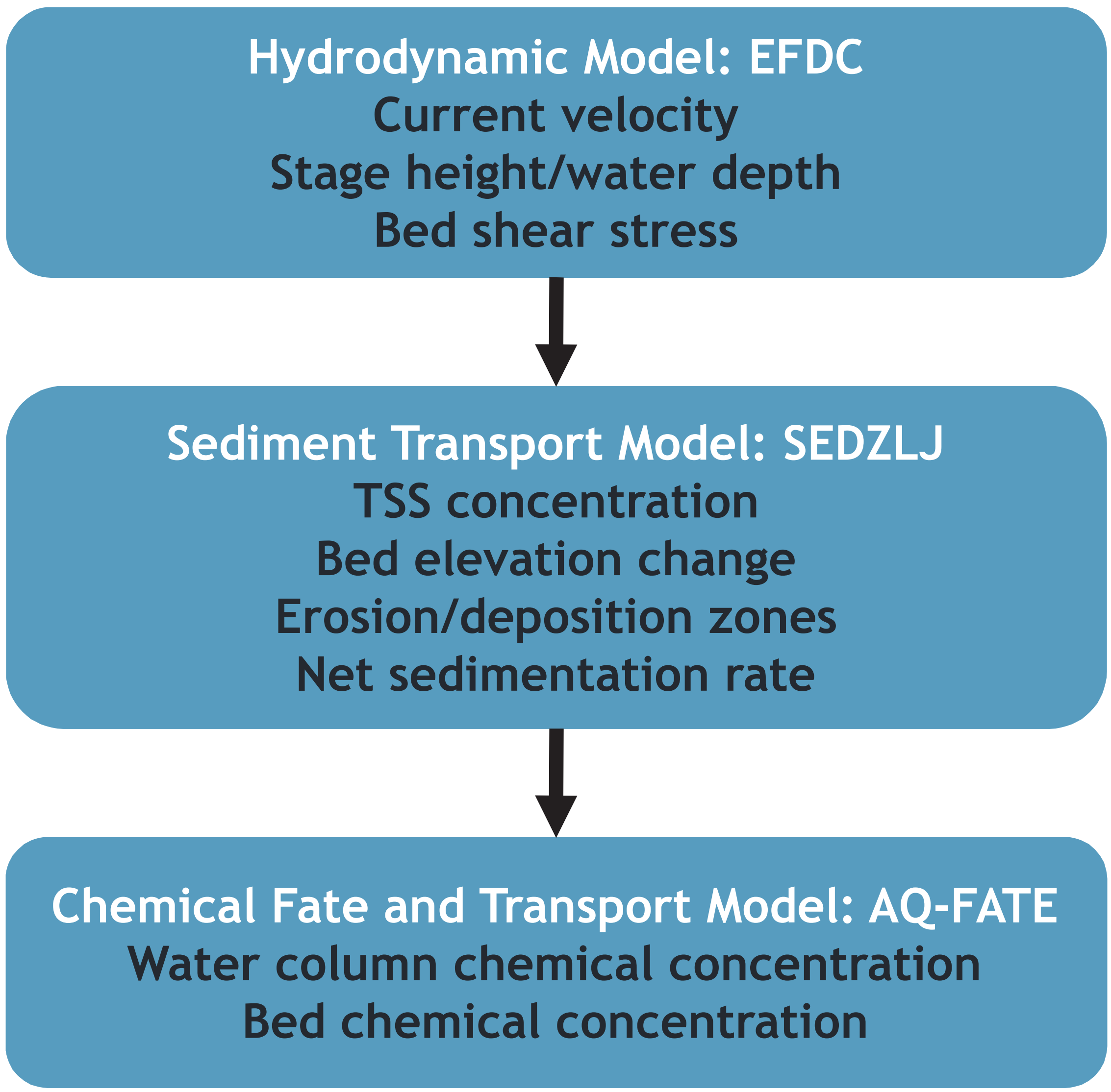
Figure 5-1
Currently Permitted Discharges to the Main Channel of Patrick Bayou and East Fork Tributary
Patrick Bayou Remedial Investigation Report
Patrick Bayou Superfund Site Remedial Investigation, Deer Park, Texas



6/12/13 eis GulfCoast\Projects\Patrick Bayou (040284-01)\Remedial Investigation Report\Figures\Figure 6-1 Fate+Transport Processes.cdr

ANCHOR QEA

Figure 6-1
Fate and Transport Processes
Patrick Bayou Remedial Investigation Report
Patrick Bayou Superfund Site Remedial Investigation, Deer Park, Texas



ANCHOR QEA

Figure 6-2
Patrick Bayou Modeling Framework
Patrick Bayou Remedial Investigation Report
Patrick Bayou Superfund Site Remedial Investigation, Deer Park, Texas

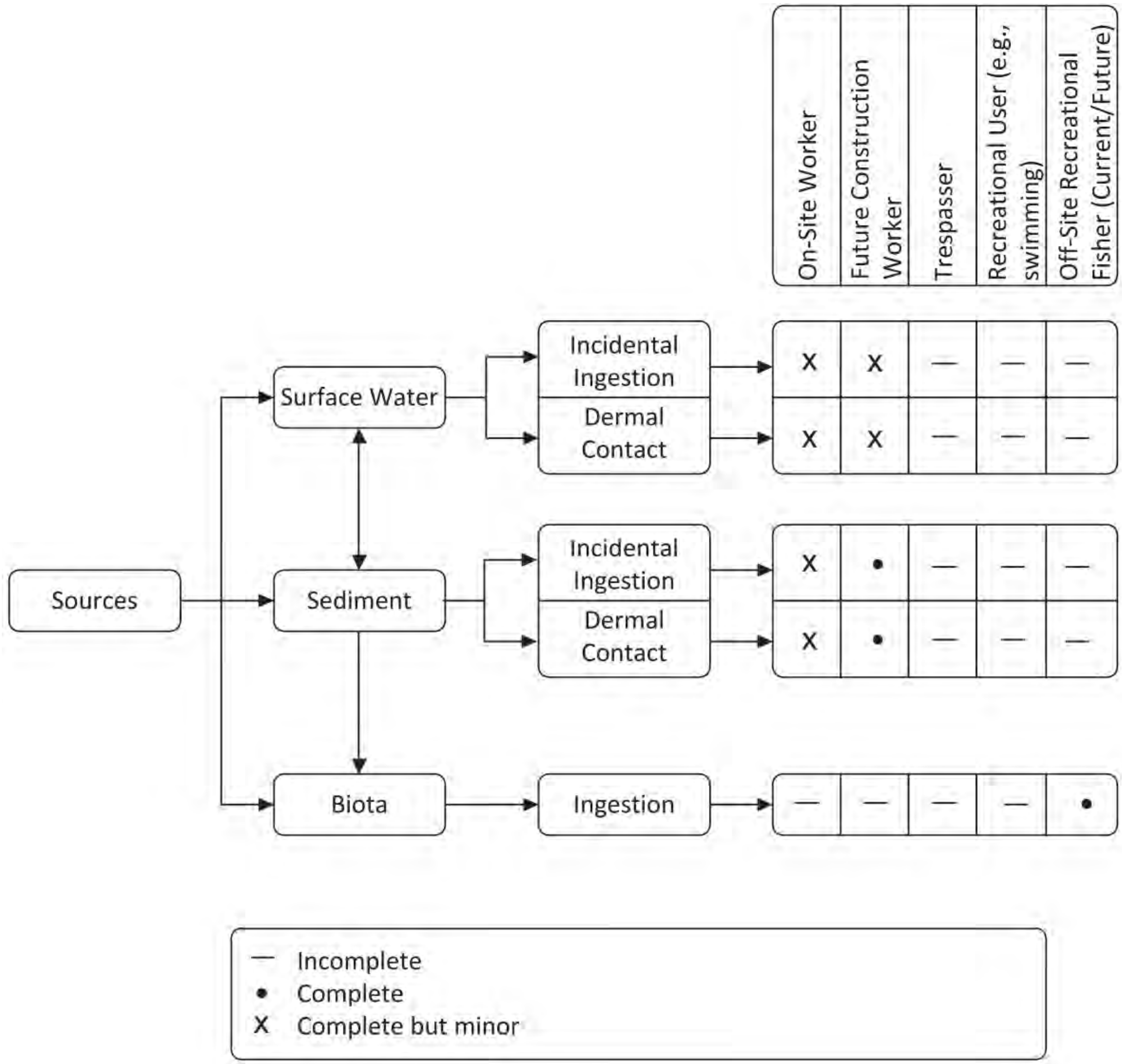


Figure 7-1
Preliminary Conceptual Site Model Included in the Baseline Human Health Risk Assessment Work Plan
Patrick Bayou Remedial Investigation Report
Patrick Bayou Superfund Site Remedial Investigation, Deer Park, Texas

Exposure Media	Exposure Route	Plants	Benthic & Aquatic Invertebrates	Fish	Amphibians & Reptiles	Birds				Mammals		Receptor Class
		Community				Piscivore	Carnivore	Omnivore	Sediment probing invertivore	Carnivore	Omnivore	Feeding Guild
						Belted Kingfisher	Composite	None[2]	Spotted Sandpiper	Mink and/or River Otter	Raccoon	Representative Species
Sediment & Pore water	Ingestion	na	●	●	□[1]	■	●	●	●	■	●	
	Direct Contact	□[1]	●	●	□[1]	□	□	□	□	■	□	
Surface Water	Ingestion	na	●	■	□[1]	■	■	■	■	■	■	
	Direct Contact	□[1]	●	●	□[1]	□	□	□	□	■	□	
Biota	Ingestion	na	●	●	□[1]	●	●	●	●	■	●	
Air	Inhalation	na	—	—	□[1]	■	■	■	■	■	■	

● Complete and significant

■ Complete and minor

□ Complete and uncertain

— Incomplete

na not applicable

1 Due to the lack of exposure and effects information for this receptor group, it will not be quantitatively assessed in the BERA

2 An omnivorous avian representative receptor was not selected; other avian feeding guilds are considered protective of this feeding guild

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Figure 7-2
Baseline Ecological Risk Assessment Conceptual Site Model
Patrick Bayou Remedial Investigation Report
Patrick Bayou Superfund Site Remedial Investigation, Deer Park, Texas

APPENDIX A
SUPPORTING NATURE AND EXTENT DATA

Appendix A-1
Results for Site Sediment Samples

Station Code	EF-001	PB001.1	PB001.2	PB001.3	PB002	PB003	PB004	PB005
Sample ID	EF001-1SC011-N	PB001.1-1SS010-091027-N	PB001.2-1SS010-091027-N	PB001.3-1SS010-091027-N	PB002-1SS010-091027-N	PB003-1SC011-N	PB004-1SS010-091027-N	PB005-1SS010-091027-N
Sample Date	10/5/2006	10/27/2009	10/27/2009	10/27/2009	10/27/2009	10/2/2006	10/27/2009	10/27/2009
Sample Type	N	N	N	N	N	N	N	N
X Coordinate	3201632.958	3202382.3842	3202624.0211	3202754.9026	3202606.9920	3202134.797	3202330.4788	3202262.1385
Y Coordinate	13831246.94	13836546.3402	13836566.3557	13836489.4987	13836435.6794	13836154.412	13836348.7826	13836144.2614
Metals (mg/kg)								
Lead	**16.3 J**	**45.0 J**	**37.6 J**	**18.6 J**	**43.2 J**	**66.7**	**41.0 J**	**33.1 J**
Semivolatile Organics (µg/kg)								
bis(2-Ethylhexyl)phthalate	3000.0 U	**5370**	**1460**	**693**	**2060**	**820.0 J**	**1070**	**1240**
PCB Congeners (mg/kg)								
Total Decachlorobiphenyl homologs (U = 1/2)	**0.0109568 J**	**1.45 J**	**0.884 J**	**1.41 J**	**1.71 J**	**0.32557**	**1.08 J**	**1.21 J**
Total Dichlorobiphenyl homologs (U = 1/2)	**0.0039675 J**	**0.19638 J**	**0.06355 J**	**0.026731 J**	**0.10089 J**	**0.02505092 J**	**0.03602 J**	**0.05388 J**
Total Heptachlorobiphenyl homologs (U = 1/2)	**0.0100349**	**0.14065 J**	**0.07316 J**	**0.03908 J**	**0.15061 J**	**0.0571166**	**0.0804 J**	**0.08264 J**
Total Hexachlorobiphenyl homologs (U = 1/2)	**0.029601**	**0.55614 J**	**0.2255 J**	**0.13669 J**	**0.34083 J**	**0.1572789**	**0.222065 J**	**0.2443 J**
Total Monochlorobiphenyl homologs (U = 1/2)	**0.000128**	**0.017955**	**0.007911**	**0.003825**	**0.015445**	**0.0021893 J**	**0.003367**	**0.00663**
Total Nonachlorobiphenyl homologs (U = 1/2)	**0.00073446 J**	**0.03298 J**	**0.02574 J**	**0.0554 J**	**0.05497 J**	**0.01006793**	**0.02171 J**	**0.02553 J**
Total Octachlorobiphenyl homologs (U = 1/2)	**0.00331**	**0.03612 J**	**0.02472 J**	**0.032034 J**	**0.048813 J**	**0.0142941 J**	**0.02316 J**	**0.02293 J**
Total Pentachlorobiphenyl homologs (U = 1/2)	**0.12535224**	**1.91594 J**	**0.59298 J**	**0.25981 J**	**0.69226 J**	**0.5592944**	**0.60737 J**	**0.6318 J**
Total Tetrachlorobiphenyl homologs (U = 1/2)	**0.2367726**	**4.05513 J**	**1.0898 J**	**0.3611 J**	**1.32187 J**	**1.1067433**	**0.88402 J**	**1.03925 J**
Total Trichlorobiphenyl homologs (U = 1/2)	**0.0859744**	**1.85332 J**	**0.561966 J**	**0.20358 J**	**0.82732 J**	**0.4539424**	**0.414358 J**	**0.51301 J**
Total PCB Congener (U = 1/2)	**0.50683 J**	**10.25461 J**	**3.54933 J**	**2.52824 J**	**5.26301 J**	**2.7115479 J**	**3.37248 J**	**3.82997 J**
Polycyclic Aromatic Hydrocarbons (mg/kg)								
Total HPAH (9 of 16) (U = 1/2)	**2.209**	**24.653**	**13.6095**	**11.0061**	**37.0414**	**8.309**	**9.679**	**13.6578**
Total LPAH (7 of 16) (U = 1/2)	**0.31**	**11.677**	**7.772**	**8.619**	**13.076**	**2.87**	**3.642**	**7.437**
Total PAH (16) (U = 1/2)	**2.519**	**36.33**	**21.3815**	**19.6251**	**50.1174**	**11.179**	**13.321**	**21.0948**

Appendix A-1
Results for Site Sediment Samples

Station Code	PB007.1	PB007.2	PB009	PB009_A	PB011_A	PB013.1	PB013.2	PB015
Sample ID	PB007.1-1SS010-091028-N	PB007.2-1SS010-091028-N	PB009-1SC011-N	PB009-1SS010-091028-N	PB011-1SS010-091028-N	PB013.1-1SS010-091028-N	PB013.2-1SS010-091028-N	PB015-1SS010-091028-N
Sample Date	10/28/2009	10/28/2009	10/2/2006	10/28/2009	10/28/2009	10/28/2009	10/28/2009	10/28/2009
Sample Type	N	N	N	N	N	N	N	N
X Coordinate	3202065.5011	3202037.3755	3201846.046	3201747.2539	3201727.2504	3201333.4751	3201420.5786	3201223.8464
Y Coordinate	13836300.0036	13836110.2965	13836186.465	13836119.3947	13836239.7593	13836187.7023	13836111.1432	13836229.0694
Metals (mg/kg)								
Lead	52.3 J	32.3 J	54.1	23.9 J	220.0 J	26.9 J	13.9 J	52.8 J
Semivolatile Organics (µg/kg)								
bis(2-Ethylhexyl)phthalate	11800.0 J	1040	630.0 J	963.0 J	1660	1530	632	1280
PCB Congeners (mg/kg)								
Total Decachlorobiphenyl homologs (U = 1/2)	1.13 J	0.994 J	0.489735	2.11 J	1.77 J	0.563 J	0.68 J	1.16 J
Total Dichlorobiphenyl homologs (U = 1/2)	0.03886 J	0.057283 J	0.023852 J	0.03901 J	0.05779 J	0.030495 J	0.01512 J	0.03751 J
Total Heptachlorobiphenyl homologs (U = 1/2)	0.09811 J	0.072037 J	0.0623654	0.07323 J	0.11041 J	0.05468 J	0.0381 J	0.10315 J
Total Hexachlorobiphenyl homologs (U = 1/2)	0.30338 J	0.22268 J	0.129187	0.22931 J	0.29688 J	0.1733 J	0.12556 J	0.29941 J
Total Monochlorobiphenyl homologs (U = 1/2)	0.003082	0.005436	0.0037419 J	0.00562	0.007381	0.003142	0.001813	0.003399
Total Nonachlorobiphenyl homologs (U = 1/2)	0.02583 J	0.02346 J	0.0118588	0.02837 J	0.03701 J	0.0121 J	0.00927 J	0.03772 J
Total Octachlorobiphenyl homologs (U = 1/2)	0.02761 J	0.02149 J	0.0131528 J	0.01978 J	0.03877 J	0.014178 J	0.01007 J	0.03088 J
Total Pentachlorobiphenyl homologs (U = 1/2)	0.95878 J	0.60078 J	0.356972	0.50971 J	0.69287 J	0.44632 J	0.30397 J	0.8444 J
Total Tetrachlorobiphenyl homologs (U = 1/2)	1.555 J	1.0535 J	0.6595246	0.74599 J	1.16958 J	0.73621 J	0.3782 J	1.39516 J
Total Trichlorobiphenyl homologs (U = 1/2)	0.54343 J	0.536772 J	0.2469424	0.34578 J	0.56736 J	0.33166 J	0.15481 J	0.5031 J
Total PCB Congener (U = 1/2)	4.68408 J	3.58743 J	1.997332 J	4.10681 J	4.74806 J	2.36508 J	1.71692 J	4.41473 J
Polycyclic Aromatic Hydrocarbons (mg/kg)								
Total HPAH (9 of 16) (U = 1/2)	10.933	16.321	4.88	101.53 J	18.9695	11.851	6.3117	9.404
Total LPAH (7 of 16) (U = 1/2)	2.966	6.477	2.292	35.274 J	9.773	5.234	3.396	3.448
Total PAH (16) (U = 1/2)	13.899	22.798	7.172	136.804 J	28.7425	17.085	9.7077	12.852

Appendix A-1
Results for Site Sediment Samples

Station Code	PB016	PB016_A	PB016_A	PB018	PB018_A	PB019	PB022	PB022_A	PB022_A
Sample ID	PB016-1SC011-N	PB016-1SS010-091101-N	PB016-1SS010-091102-N	PB018-1SC011-N	PB018-1SS010-091101-N	PB019-1SS010-091101-N	PB022-1SC011-N	PB022-1SS010-091101-D	PB022-1SS010-091101-N
Sample Date	10/3/2006	11/1/2009	11/1/2009	10/3/2006	11/1/2009	11/1/2009	10/3/2006	11/1/2009	11/1/2009
Sample Type	N	N	N	N	N	N	N	FD	N
X Coordinate	3201172.392	3201140.0114	3201140.0114	3201082.264	3201146.8550	3201281.6017	3201095.007	3201174.1294	3201174.1294
Y Coordinate	13836105.369	13836081.5392	13836081.5392	13835866.867	13835702.1476	13835711.9947	13835492.515	13835456.7389	13835456.7389
Metals (mg/kg)									
Lead	25	57.2 J	--	100	234.0 J	23.9 J	98.7	26.9 J	25.4 J
Semivolatile Organics (µg/kg)									
bis(2-Ethylhexyl)phthalate	490.0 J	949	--	1400.0 J	959	991	1200.0 J	812	812
PCB Congeners (mg/kg)									
Total Decachlorobiphenyl homologs (U = 1/2)	1.03535	--	0.359 J	1.60864	1.34 J	0.883 J	0.737943	0.318 J	0.346 J
Total Dichlorobiphenyl homologs (U = 1/2)	0.03286055 J	--	0.136077 J	0.24851328 J	0.044982 J	0.03634 J	0.0574774 J	0.023376 J	0.02391 J
Total Heptachlorobiphenyl homologs (U = 1/2)	0.1146702	--	0.13894 J	0.228662	0.07095 J	0.05791 J	0.09503775	0.09345 J	0.05162 J
Total Hexachlorobiphenyl homologs (U = 1/2)	0.2448563	--	0.60843 J	0.5302589	0.1916 J	0.17819 J	0.3084513	0.22873 J	0.15339 J
Total Monochlorobiphenyl homologs (U = 1/2)	0.00302685 J	--	0.005208	0.03041121 J	0.006724 J	0.005832	0.00892675 J	0.002648	0.002446 J
Total Nonachlorobiphenyl homologs (U = 1/2)	0.04476029	--	0.01016	0.0779957	0.02558	0.02111	0.01687305	0.00981	0.00846
Total Octachlorobiphenyl homologs (U = 1/2)	0.03778189 J	--	0.02706	0.0686495 J	0.020918	0.01736	0.0273494 J	0.03956	0.0135
Total Pentachlorobiphenyl homologs (U = 1/2)	0.3788753	--	2.36201 J	1.68068006	0.38246 J	0.374255 J	0.82165498	0.51479 J	0.44085 J
Total Tetrachlorobiphenyl homologs (U = 1/2)	0.6394061	--	5.07358 J	5.26898438	0.63588 J	0.61535 J	1.4547235	0.77432 J	0.82266 J
Total Trichlorobiphenyl homologs (U = 1/2)	0.32779148	--	2.369272 J	1.78393472	0.36094 J	0.31624 J	1.23938738 J	0.30151 J	0.32115 J
Total PCB Congener (U = 1/2)	2.8593789 J	--	11.08974 J	11.526729 J	3.08004 J	2.50559 J	4.7678244 J	2.30621 J	2.18399 J
Polycyclic Aromatic Hydrocarbons (mg/kg)									
Total HPAH (9 of 16) (U = 1/2)	7.234	15.287	--	34.75	38.52	11.7754	8.449	10.994	10.859
Total LPAH (7 of 16) (U = 1/2)	3.14	5.882	--	14.1	8.741	6.438	4.64	4.17	4.64
Total PAH (16) (U = 1/2)	10.374	21.169	--	48.85	47.261	18.2134	13.089	15.164	15.499

Appendix A-1
Results for Site Sediment Samples

Station Code	PB023_A	PB023_A	PB024_A	PB026	PB028	PB030	PB032	PB034	PB036
Sample ID	PB023-1SS010-091030-D	PB023-1SS010-091030-N	PB024-1SS010-091030-N	PB026-1SS010-091030-N	PB028-1SS010-091030-N	PB030-1SC011-N	PB032-1SS010-091030-N	PB034-1SS010-091030-N	PB036-1SC011-N
Sample Date	10/30/2009	10/30/2009	10/30/2009	10/30/2009	10/30/2009	10/4/2006	10/30/2009	10/30/2009	10/4/2006
Sample Type	FD	N	N	N	N	N	N	N	N
X Coordinate	3201315.1973	3201315.1973	3201180.8567	3201331.5617	3201355.6226	3201358.784	3201368.6522	3201387.6450	3201370.125
Y Coordinate	13835429.2411	13835429.2411	13835181.4775	13835155.0673	13834855.4834	13834704.397	13834541.6071	13834242.2769	13834129.846
Metals (mg/kg)									
Lead	**20.4 J**	**20.8 J**	**32.3 J**	**187.0 J**	**41.9 J**	**35.8**	**112.0 J**	**142.0 J**	**296**
Semivolatile Organics (µg/kg)									
bis(2-Ethylhexyl)phthalate	**1010**	**1980**	**1920.0 J**	**1020.0 J**	**458.0 J**	2000.0 U	**3320.0 J**	**1300.0 J**	12000.0 U
PCB Congeners (mg/kg)									
Total Decachlorobiphenyl homologs (U = 1/2)	**6.01 J**	**3.7 J**	**0.649 J**	**117.0 J**	**0.423 J**	**0.00587555**	**57.6 J**	**1.77 J**	**0.388182**
Total Dichlorobiphenyl homologs (U = 1/2)	**0.03587 J**	**0.02486 J**	**0.0548 J**	**0.30505 J**	**0.01171 J**	**0.01641866 J**	**0.05598 J**	**0.03924 J**	**0.2942119 J**
Total Heptachlorobiphenyl homologs (U = 1/2)	**0.11143 J**	**0.0928 J**	**0.08686 J**	**0.37611 J**	**0.028252**	**0.011291**	**0.06034 J**	**0.15129 J**	**0.31899326**
Total Hexachlorobiphenyl homologs (U = 1/2)	**0.28676 J**	**0.22319 J**	**0.2484 J**	**0.68046 J**	**0.07771**	**0.0433986**	**0.13679 J**	**0.43881 J**	**0.6655925**
Total Monochlorobiphenyl homologs (U = 1/2)	**0.008056 J**	**0.004142 J**	**0.008055**	**0.2396 J**	**0.001712**	**0.0008321**	**0.054 J**	**0.01904**	**0.10016169 J**
Total Nonachlorobiphenyl homologs (U = 1/2)	**0.07013 J**	**0.03574 J**	**0.04917 J**	**2.761 J**	**0.00817**	**0.0004283**	**0.3603 J**	**0.04623 J**	**0.01239598**
Total Octachlorobiphenyl homologs (U = 1/2)	**0.03538**	**0.02538**	**0.02443**	**0.63401 J**	**0.00806**	**0.0023116 J**	**0.05125**	**0.04462**	**0.0490955 J**
Total Pentachlorobiphenyl homologs (U = 1/2)	**0.69182 J**	**0.3729 J**	**0.58329 J**	**0.75505 J**	**0.198844 J**	**0.16169013**	**0.14005 J**	**1.10863 J**	**1.6420704 J**
Total Tetrachlorobiphenyl homologs (U = 1/2)	**1.035 J**	**0.55458 J**	**0.96918 J**	**0.8295 J**	**0.32101 J**	**0.2906259**	**0.0826 J**	**1.64932 J**	**4.15194737 J**
Total Trichlorobiphenyl homologs (U = 1/2)	**0.31962 J**	**0.25462 J**	**0.48799 J**	**0.59773 J**	**0.13802 J**	**0.121143**	**0.0333**	**0.601489 J**	**2.38283484 J**
Total PCB Congener (U = 1/2)	**8.60408 J**	**5.28821 J**	**3.16118 J**	**124.17851 J**	**1.21648 J**	**0.6540148 J**	**58.57462 J**	**5.86866 J**	**10.0054854 J**
Polycyclic Aromatic Hydrocarbons (mg/kg)									
Total HPAH (9 of 16) (U = 1/2)	**8.7538**	**9.1311**	**15.093 J**	**50.9616**	**2.9881**	**7.409**	**156.185**	**17.6704**	**18.88**
Total LPAH (7 of 16) (U = 1/2)	**4.004**	**4.968**	**6.973**	**63.24**	**1.0514 J**	**2.427**	**23.761 J**	**14.286 J**	**41**
Total PAH (16) (U = 1/2)	**12.7578**	**14.0991**	**22.066 J**	**114.2016**	**4.0395 J**	**9.836**	**179.946 J**	**31.9564 J**	**59.88**

Appendix A-1
Results for Site Sediment Samples

Station Code	PB037	PB041_A	PB042	PB043	PB044_A	PB047.1	PB047.2	PB048
Sample ID	PB037-1SS010-091030-N	PB041-1SS010-091030-N	PB042-1SC011-N	PB043-1SS010-091030-N	PB044-1SS010-091030-N	PB047.1-1SS010-091030-N	PB047.2-1SS010-091030-N	PB048-1SC011-N
Sample Date	10/30/2009	10/30/2009	10/4/2006	10/30/2009	10/30/2009	10/30/2009	10/30/2009	10/4/2006
Sample Type	N	N	N	N	N	N	N	N
X Coordinate	3201399.4292	3201410.6060	3201345.24	3201451.0315	3201663.5416	3201454.2006	3201656.8574	3201486.842
Y Coordinate	13833936.8351	13833634.6932	13833564.421	13833347.5606	13833285.4731	13833042.2356	13833055.7842	13832966.961
Metals (mg/kg)								
Lead	47.5 J	52.4 J	119	24.6 J	37.7 J	24.9 J	34.6 J	118
Semivolatile Organics (µg/kg)								
bis(2-Ethylhexyl)phthalate	4780.0 J	1450.0 J	920.0 J	1270.0 J	1880.0 J	1240.0 J	1530.0 J	3500
PCB Congeners (mg/kg)								
Total Decachlorobiphenyl homologs (U = 1/2)	0.315 J	0.103 J	0.0163665	0.0241 J	0.177 J	0.0382 J	0.0931 J	0.0255078
Total Dichlorobiphenyl homologs (U = 1/2)	0.11573 J	0.11345 J	0.08726666 J	0.075472 J	0.13398 J	0.14645 J	0.020807 J	0.0375432 J
Total Heptachlorobiphenyl homologs (U = 1/2)	0.15271 J	0.18574 J	0.1064109	0.108001 J	0.1617 J	0.30024 J	0.06463 J	0.12433248
Total Hexachlorobiphenyl homologs (U = 1/2)	0.64449 J	0.78202 J	0.20178429	0.51934 J	0.53429 J	1.75782 J	0.22457 J	0.2335648
Total Monochlorobiphenyl homologs (U = 1/2)	0.005981	0.006205	0.00510511	0.002168	0.009896	0.007086	0.000905	0.00475984 J
Total Nonachlorobiphenyl homologs (U = 1/2)	0.01117	0.01537	0.0022719	0.00331	0.00697	0.007931	0.00518	0.01067707
Total Octachlorobiphenyl homologs (U = 1/2)	0.033262	0.04664 J	0.01896501 J	0.02104	0.029971	0.04431	0.0143	0.02938106 J
Total Pentachlorobiphenyl homologs (U = 1/2)	2.52551 J	2.86643 J	0.4117092	2.00968 J	1.61535 J	5.73447 J	0.75492 J	0.833127
Total Tetrachlorobiphenyl homologs (U = 1/2)	4.280866 J	4.43848 J	1.17402011	3.5992 J	3.26742 J	8.68575 J	1.22183 J	1.63015893
Total Trichlorobiphenyl homologs (U = 1/2)	1.85666 J	1.76465 J	0.90517477	1.34338 J	1.545137 J	3.14267 J	0.41884 J	0.5346726 J
Total PCB Congener (U = 1/2)	9.94138 J	10.32198 J	2.9290745 J	7.70569 J	7.48171 J	19.86491 J	2.81908 J	3.4637247 J
Polycyclic Aromatic Hydrocarbons (mg/kg)								
Total HPAH (9 of 16) (U = 1/2)	11.6	16.613	6.867	12.665	13.739	15.48	6.457	2.879
Total LPAH (7 of 16) (U = 1/2)	4.056 J	4.774 J	1.503	2.6953 J	4.626 J	2.958 J	1.0829 J	0.486
Total PAH (16) (U = 1/2)	15.656 J	21.387 J	8.37	15.3603 J	18.365 J	18.438 J	7.5399 J	3.365

Appendix A-1
Results for Site Sediment Samples

Station Code	PB048_A	PB049	PB049	PB053_A	PB056	PB057	PB057_A	PB059.1
Sample ID	PB048-1SS010-091031-N	PB049-1SS010-091031-D	PB049-1SS010-091031-N	PB053-1SS010-091031-N	PB056-1SS010-091031-N	PB057-1SC011-N	PB057-1SS010-091031-N	PB059.1-1SS010-091102-N
Sample Date	10/31/2009	10/31/2009	10/31/2009	10/31/2009	10/31/2009	10/5/2006	10/31/2009	11/2/2009
Sample Type	N	FD	N	N	N	N	N	N
X Coordinate	3201635.5547	3201435.3433	3201435.3433	3201421.7211	3201402.6901	3201467.145	3201634.7257	3201531.6282
Y Coordinate	13832859.6311	13832751.7292	13832751.7292	13832443.5506	13832184.9773	13832096.911	13832087.9098	13831850.4179
Metals (mg/kg)								
Lead	43.2 J	38.0 J	34.9 J	70.9 J	31.9 J	50.4 J	22.9 J	33.3 J
Semivolatile Organics (µg/kg)								
bis(2-Ethylhexyl)phthalate	1620	2460	2120	2300	2230	1900.0 J	1470	1030
PCB Congeners (mg/kg)								
Total Decachlorobiphenyl homologs (U = 1/2)	0.14 J	0.0331 J	0.0368 J	0.0482 J	0.0422 J	0.00165563	0.0209 J	0.00438
Total Dichlorobiphenyl homologs (U = 1/2)	0.03659 J	0.040434 J	0.04454 J	4.36555 J	0.07234 J	0.11426514 J	0.02836 J	0.6336 J
Total Heptachlorobiphenyl homologs (U = 1/2)	0.08286 J	0.06844 J	0.07391 J	0.41431 J	0.10204 J	0.06475021	0.03122	0.41964 J
Total Hexachlorobiphenyl homologs (U = 1/2)	0.26005 J	0.2879 J	0.28138 J	2.78208 J	0.40943 J	0.23536996	0.1453 J	2.2639 J
Total Monochlorobiphenyl homologs (U = 1/2)	0.001831 J	0.00139	0.001443	0.5721 J	0.002335	0.0111326	0.001632 J	0.022944
Total Nonachlorobiphenyl homologs (U = 1/2)	0.00654	0.004738	0.00488	0.01838	0.004057	0.00143416 J	0.001541	0.009037
Total Octachlorobiphenyl homologs (U = 1/2)	0.02268 J	0.01689	0.018179	0.10291 J	0.022993	0.0132805	0.00768	0.07669 J
Total Pentachlorobiphenyl homologs (U = 1/2)	0.98088 J	0.99847 J	1.14179 J	17.15999 J	1.68777 J	1.22852844	0.67015 J	10.9524 J
Total Tetrachlorobiphenyl homologs (U = 1/2)	1.78507 J	1.82141 J	2.17614 J	48.5155 J	3.46905 J	2.62619797	1.18102 J	22.13068 J
Total Trichlorobiphenyl homologs (U = 1/2)	0.66357 J	0.6933 J	0.79616 J	21.04685 J	1.294959 J	1.19015518	0.46592 J	10.11851 J
Total PCB Congener (U = 1/2)	3.98006 J	3.96607 J	4.57521 J	95.02585 J	7.10716 J	5.4867698 J	2.55373 J	46.63178 J
Polycyclic Aromatic Hydrocarbons (mg/kg)								
Total HPAH (9 of 16) (U = 1/2)	6.767	5.306 J	7.373	54.154	15.198	17.85	10.282	32.33
Total LPAH (7 of 16) (U = 1/2)	1.1117	2.324 J	1.6109	192.27	1.6515	28.79	0.7263	8.833
Total PAH (16) (U = 1/2)	7.8787	7.63 J	8.9839	246.424	16.8495	46.64	11.0083	41.163

Appendix A-1
Results for Site Sediment Samples

Station Code	PB059.2	PB063	PB063.1	PB063.2	PB064	PB066	PB068	PB069
Sample ID	PB059.2-1SS010-091031-N	PB063-1SC011-N	PB063.1-1SS010-091031-N	PB063.2-1SS010-091102-N	PB064-1SS010-091102-N	PB066-1SS010-091101-N	PBUC076-1SS010-20110804-N	PB069-1SS010-091101-N
Sample Date	10/31/2009	10/5/2006	10/31/2009	11/2/2009	11/2/2009	11/1/2009	8/4/2011	11/1/2009
Sample Type	N	N	N	N	N	N	N	N
X Coordinate	3201640.7239	3201536.273	3201497.4803	3201553.0822	3201628.7185	3201431.2755	3201209.861	3201160.2007
Y Coordinate	13831857.0149	13831339.735	13831523.9045	13831552.2764	13831275.6688	13831275.6811	13831121.51	13830971.1845
Metals (mg/kg)								
Lead	**37.0 J**	**13.3 J**	**57.0 J**	**39.0 J**	**9.72 J**	**24.5 J**	--	**22.7 J**
Semivolatile Organics (µg/kg)								
bis(2-Ethylhexyl)phthalate	**2290**	2000.0 U	**577**	**2390**	**198.0 J**	**922**	--	**1140**
PCB Congeners (mg/kg)								
Total Decachlorobiphenyl homologs (U = 1/2)	**0.00726**	**0.00073948**	**0.00276**	**0.00715**	**0.0048**	**0.00349**	--	**0.0033**
Total Dichlorobiphenyl homologs (U = 1/2)	**0.03727 J**	**0.001556 J**	**0.814725 J**	**0.030557 J**	**0.00303 J**	**0.09502 J**	--	**0.97011 J**
Total Heptachlorobiphenyl homologs (U = 1/2)	**0.0539**	**0.005243**	**0.24219 J**	**0.04087**	**0.004542 J**	**0.060235 J**	--	**0.45654 J**
Total Hexachlorobiphenyl homologs (U = 1/2)	**0.27358 J**	**0.01596**	**1.17884 J**	**0.16586 J**	**0.01603**	**0.33361 J**	--	**1.75775 J**
Total Monochlorobiphenyl homologs (U = 1/2)	**0.00145**	**0.000058 J**	**0.06347 J**	**0.001486**	**0.000115 J**	**0.0063**	--	**0.043349 J**
Total Nonachlorobiphenyl homologs (U = 1/2)	**0.002161**	**0.0002393 J**	**0.006104**	**0.00148**	**0.00036**	**0.00184**	--	**0.01055**
Total Octachlorobiphenyl homologs (U = 1/2)	**0.01225**	**0.00132**	**0.04946**	**0.00825**	**0.00104 J**	**0.01328**	--	**0.100914 J**
Total Pentachlorobiphenyl homologs (U = 1/2)	**1.17374 J**	**0.0637613**	**6.53876 J**	**0.64129 J**	**0.0581**	**1.47543 J**	--	**8.39452 J**
Total Tetrachlorobiphenyl homologs (U = 1/2)	**2.01383 J**	**0.1058964**	**15.99905 J**	**1.30072 J**	**0.12851 J**	**3.25604 J**	--	**21.29636 J**
Total Trichlorobiphenyl homologs (U = 1/2)	**0.5896 J**	**0.0316709**	**6.91255 J**	**0.44932 J**	**0.04587 J**	**1.34074 J**	--	**10.55895 J**
Total PCB Congener (U = 1/2)	**4.16504 J**	**0.226445 J**	**31.80792 J**	**2.64698 J**	**0.26239 J**	**6.58598 J**	--	**43.59235 J**
Polycyclic Aromatic Hydrocarbons (mg/kg)								
Total HPAH (9 of 16) (U = 1/2)	**4.5125**	**7.731**	**56.987**	**6.881**	**10.733**	**11.675**	**28.156**	**23.218**
Total LPAH (7 of 16) (U = 1/2)	**2.509**	**0.974**	**23.313**	**0.7556**	**5.828**	**1.5078**	**61.5**	**41.32**
Total PAH (16) (U = 1/2)	**7.0215**	**8.705**	**80.3**	**7.6366**	**16.561**	**13.1828**	**89.656**	**64.538**

Appendix A-1
Results for Site Sediment Samples

Station Code	PB069.1	PB070_A	PB073	PB074	PB076.1	PB077	PB081	PB081.1
Sample ID	PBUC070-1SS008-20110804-N	PBUC042-1SS010-20110802-N	PB073-1SC011-N	PB074-1SS010-091101-N	PBUC012-1SS010-20110802-N	PB077-1SS007-N	PB081-1SS010-091103-N	PBUC053-1SS010-20110803-D
Sample Date	8/4/2011	8/2/2011	10/5/2006	11/1/2009	8/2/2011	10/5/2006	11/3/2009	8/3/2011
Sample Type	N	N	N	N	N	N	N	FD
X Coordinate	3201205.859	3201087.255	3201037.34	3200828.0183	3200744.033	3200738.387	3200761.3787	3200772.123
Y Coordinate	13830973.3	13830903.51	13830742.28	13830463.2171	13830426.95	13830380.106	13830005.1879	13829983.6
Metals (mg/kg)								
Lead	--	--	**32.2**	**26.3 J**	--	**11.2**	**335.0 J**	--
Semivolatile Organics (µg/kg)								
bis(2-Ethylhexyl)phthalate	--	--	**370.0 J**	**1790**	--	2000.0 U	**1220.0 J**	--
PCB Congeners (mg/kg)								
Total Decachlorobiphenyl homologs (U = 1/2)	--	--	**0.00069447 J**	0.000592 U	--	**0.000017**	**0.0117**	--
Total Dichlorobiphenyl homologs (U = 1/2)	--	--	**0.1198437 J**	**0.05475 J**	--	**0.00058472**	**0.899892 J**	--
Total Heptachlorobiphenyl homologs (U = 1/2)	--	--	**0.11820628 J**	**0.0494 J**	--	**0.001808**	**0.37654 J**	--
Total Hexachlorobiphenyl homologs (U = 1/2)	--	--	**0.4706387 J**	**0.38 J**	--	**0.00219**	**1.17 J**	--
Total Monochlorobiphenyl homologs (U = 1/2)	--	--	**0.00779755 J**	**0.003885**	--	**0.0000394 J**	**0.22184 J**	--
Total Nonachlorobiphenyl homologs (U = 1/2)	--	--	**0.00864904 J**	**0.00052**	--	**0.0001403 J**	**0.006568**	--
Total Octachlorobiphenyl homologs (U = 1/2)	--	--	**0.04800434 J**	**0.00444 J**	--	**0.000785**	**0.074765 J**	--
Total Pentachlorobiphenyl homologs (U = 1/2)	--	--	**2.11107459 J**	**0.865072 J**	--	**0.001791**	**3.99839 J**	--
Total Tetrachlorobiphenyl homologs (U = 1/2)	--	--	**5.10964985 J**	**1.27791 J**	--	**0.0022883**	**9.77495 J**	--
Total Trichlorobiphenyl homologs (U = 1/2)	--	--	**2.15886121 J**	**0.6396 J**	--	**0.001243**	**5.18319 J**	--
Total PCB Congener (U = 1/2)	--	--	**10.1534197 J**	**3.27587 J**	--	**0.01088 J**	**21.71783 J**	--
Polycyclic Aromatic Hydrocarbons (mg/kg)								
Total HPAH (9 of 16) (U = 1/2)	**12.869**	**6.34 J**	**7.531**	**3.6042**	**26.433**	**0.00833 J**	**168.118 J**	**73.346**
Total LPAH (7 of 16) (U = 1/2)	**3.9981**	**1.4027 J**	**3.14**	**1.1152**	**3.5493**	**0.00808 J**	**1138.4**	**402.4**
Total PAH (16) (U = 1/2)	**16.8671**	**7.7427 J**	**10.671**	**4.7194**	**29.9823**	**0.01641 J**	**1306.518 J**	**475.746**

Appendix A-1
Results for Site Sediment Samples

Station Code	PB081.1	PB082	PB093	PB097	PB101_A
Sample ID	PBUC053-1SS010-20110803-N	PBUC055-1SS010-20110803-N	PB093-1SS010-091103-N	PB097-1SS010-091103-N	PB101-1SS010-091103-N
Sample Date	8/3/2011	8/3/2011	11/3/2009	11/3/2009	11/3/2009
Sample Type	N	N	N	N	N
X Coordinate	3200772.123	3200751.881	3200970.4291	3201103.1242	3201287.2658
Y Coordinate	13829983.6	13829914.32	13828894.7843	13828566.1540	13828181.2285
Metals (mg/kg)					
Lead	--	--	36.3 J	13.1 J	172.0 J
Semivolatile Organics (µg/kg)					
bis(2-Ethylhexyl)phthalate	--	--	245	266	132.0 J
PCB Congeners (mg/kg)					
Total Decachlorobiphenyl homologs (U = 1/2)	--	--	0.000482	0.000331	0.000379
Total Dichlorobiphenyl homologs (U = 1/2)	--	--	0.06081 J	0.015357 J	0.01907 J
Total Heptachlorobiphenyl homologs (U = 1/2)	--	--	0.01045 J	0.00874	0.00173 J
Total Hexachlorobiphenyl homologs (U = 1/2)	--	--	0.04218 J	0.03741 J	0.00717 J
Total Monochlorobiphenyl homologs (U = 1/2)	--	--	0.000718	0.000215	0.00024
Total Nonachlorobiphenyl homologs (U = 1/2)	--	--	0.00024	0.000448	0.000079
Total Octachlorobiphenyl homologs (U = 1/2)	--	--	0.001566 J	0.002506 J	0.00043 J
Total Pentachlorobiphenyl homologs (U = 1/2)	--	--	0.13025 J	0.21821 J	0.047536
Total Tetrachlorobiphenyl homologs (U = 1/2)	--	--	0.54146 J	0.98996 J	0.19269 J
Total Trichlorobiphenyl homologs (U = 1/2)	--	--	0.51452 J	0.38034 J	0.13665 J
Total PCB Congener (U = 1/2)	--	--	1.30267 J	1.65353 J	0.40598 J
Polycyclic Aromatic Hydrocarbons (mg/kg)					
Total HPAH (9 of 16) (U = 1/2)	60.807	6.3888 J	1.6967	1.3193	5.1753
Total LPAH (7 of 16) (U = 1/2)	313.9	3.7191 J	0.24841	0.11589 J	0.8501
Total PAH (16) (U = 1/2)	374.707	10.1079 J	1.94511	1.43519 J	6.0254

Notes:
Bold = Detected result
J = Estimated value
N = Normal Field Sample FD = Field Duplicate
U = Compound analyzed, but not detected above detection limit
µg/kg = micrograms per kilogram
mg/kg = milligrams per kilogram
Totals are calculated as the sum of all detected results and half of the **detection limit** of undetected results (U=1/2).
Total LPAH (Low PAH) are the total of Naphthalene, Acenaphthylene, Acenaphthene, Fluorene, Phenanthrene, Anthracene, and 2-Methylnapthalene.
Total HPAH (High PAH) are the total of Fluoranthene, Pyrene, Benzo(a)anthracene, Chrysene, Benzofluoranthenes, Benzo(a)pyrene, Indeno(1,2,3-c,d)pyrene, Dibenzo(a,h)anthracene and Benzo(g,h,i)perylene.
Total PAH are the total of Naphthalene, Acenaphthylene, Acenaphthene, Fluorene, Phenanthrene, Anthracene, Fluoranthene, Pyrene, Benzo(a)anthracene, Chrysene, Benzofluoranthenes, Benzo(a)pyrene, Indeno(1,2,3-c,d)pyrene, Dibenzo(a,h)anthracene, and Benzo(g,h,i)perylene, and 2-Methylnapthalene.

Appendix A-2
Results for Surface Sediment Samples Upstream of the Site

Station Code	EF-008	EF-008	PB119	PB119.1	PB119.1	PB119.1	PB119.2
Sample ID	EF008-1SS002-D	EF008-1SS002-N	PB119-1SS002-N	PBUCCLA-1SC030-20110805-N	PBUCCLA-1SC060-20110805-N	PBUCCLA-1SC090-20110805-N	PBUCCLB-1SS010-20110805-N
Sample Date	11/6/2006	11/6/2006	11/6/2006	8/5/2011	8/5/2011	8/5/2011	8/5/2011
Sample Type	FD	N	N	N	N	N	N
X Coordinate	3202123.3	3202123.3	3201523.9	3201558.2	3201558.2	3201558.2	3201540.45
Y Coordinate	13830924	13830924	13826335.7	13826344.91	13826344.91	13826344.91	13826348.66
Metals (mg/kg)							
Lead	**8.42**	**7.29**	**201**	**19.4 J**	**16.3 J**	**23.5 J**	**17.6 J**
PCB Congeners (mg/kg)							
Total Decachlorobiphenyl homologs (U = 1/2)	--	--	--	**0.000085**	**0.000254**	**0.000268**	**0.00001**
Total Dichlorobiphenyl homologs (U = 1/2)	--	--	--	**0.00012 J**	**0.000105 J**	**0.000141 J**	**0.000454 J**
Total Heptachlorobiphenyl homologs (U = 1/2)	--	--	--	**0.001667 J**	**0.00259 J**	**0.00274 J**	**0.000572 J**
Total Hexachlorobiphenyl homologs (U = 1/2)	--	--	--	**0.00513 J**	**0.003614 J**	**0.00422 J**	**0.00167 J**
Total Monochlorobiphenyl homologs (U = 1/2)	--	--	--	0.000004 U	0.000004 U	0.000004 U	0.000004 U
Total Nonachlorobiphenyl homologs (U = 1/2)	--	--	--	**0.000083 J**	**0.00009 J**	**0.000092 J**	**0.000019**
Total Octachlorobiphenyl homologs (U = 1/2)	--	--	--	**0.000463 J**	**0.000678 J**	**0.0007 J**	**0.00013**
Total Pentachlorobiphenyl homologs (U = 1/2)	--	--	--	**0.00572 J**	**0.002412 J**	**0.00325 J**	**0.002832 J**
Total Tetrachlorobiphenyl homologs (U = 1/2)	--	--	--	**0.00288 J**	**0.001108 J**	**0.00117 J**	**0.00497 J**
Total Trichlorobiphenyl homologs (U = 1/2)	--	--	--	**0.000979 J**	**0.000223 J**	**0.000269 J**	**0.00355 J**
Total PCB Congener (U = 1/2)	--	--	--	**0.01713 J**	**0.01108 J**	**0.01285 J**	**0.01422 J**
Polycyclic Aromatic Hydrocarbons (mg/kg)							
Total HPAH (9 of 16) (U = 1/2)	**0.1798 J**	**0.4104 J**	**7.999**	**11.996**	**2.0185 J**	**4.3314**	**27.517**
Total LPAH (7 of 16) (U = 1/2)	**0.0233 J**	**0.063 J**	**0.9359 J**	**1.12813 J**	**0.25015 J**	**0.40767**	**4.3638**
Total PAH (16) (U = 1/2)	**0.2031 J**	**0.4734 J**	**8.9349 J**	**13.12413 J**	**2.26865 J**	**4.73907**	**31.8808**

Appendix A-2
Results for Surface Sediment Samples Upstream of the Site

Station Code	PB119.3	PB119.3	PB119.4	PB119.5	PB123	SE-002
Sample ID	PBUCCLC-1SS010-20110805-D	PBUCCLC-1SS010-20110805-N	PBUCCLD-1SS010-20110805-N	PBUCCLE-1SS010-20110805-N	PB123-1SS002-N	SE002-1SS002-N
Sample Date	8/5/2011	8/5/2011	8/5/2011	8/5/2011	11/6/2006	11/7/2006
Sample Type	FD	N	N	N	N	N
X Coordinate	3201530.99	3201530.99	3201525.09	3201515.69	3201431.1	3201879.4
Y Coordinate	13826350.5	13826350.5	13826351.37	13826352.04	13825966.5	13826229.6
Metals (mg/kg)						
Lead	**18.5 J**	**11.6 J**	**102 J**	**42 J**	**9.9**	**80.6**
PCB Congeners (mg/kg)						
Total Decachlorobiphenyl homologs (U = 1/2)	**0.000021 J**	**0.000015**	**0.000012 J**	**0.000034**	--	--
Total Dichlorobiphenyl homologs (U = 1/2)	**0.000182 J**	**0.000195 J**	**0.00041**	**0.00053 J**	--	--
Total Heptachlorobiphenyl homologs (U = 1/2)	**0.00071 J**	**0.00077 J**	**0.000835 J**	**0.001585 J**	--	--
Total Hexachlorobiphenyl homologs (U = 1/2)	**0.0024 J**	**0.001842 J**	**0.00171 J**	**0.00364 J**	--	--
Total Monochlorobiphenyl homologs (U = 1/2)	0.000005 U	0.000002 U	0.000005 U	**0.000013 J**	--	--
Total Nonachlorobiphenyl homologs (U = 1/2)	**0.00003 J**	**0.000019**	**0.000021**	**0.000065**	--	--
Total Octachlorobiphenyl homologs (U = 1/2)	**0.000253 J**	**0.000171 J**	**0.000174 J**	**0.00042 J**	--	--
Total Pentachlorobiphenyl homologs (U = 1/2)	**0.00299 J**	**0.00248 J**	**0.002287 J**	**0.00476 J**	--	--
Total Tetrachlorobiphenyl homologs (U = 1/2)	**0.00223 J**	**0.0018 J**	**0.002993 J**	**0.00373 J**	--	--
Total Trichlorobiphenyl homologs (U = 1/2)	**0.00145**	**0.0011**	**0.002895 J**	**0.002592 J**	--	--
Total PCB Congener (U = 1/2)	**0.01028 J**	**0.00838 J**	**0.01134 J**	**0.01736 J**	--	--
Polycyclic Aromatic Hydrocarbons (mg/kg)						
Total HPAH (9 of 16) (U = 1/2)	**6.166**	**11.501**	**12.073**	**46.442 J**	**5.846 J**	**1.122**
Total LPAH (7 of 16) (U = 1/2)	**0.50148 J**	**1.0581**	**1.68434 J**	**5.066 J**	**0.5348 J**	**0.0859 J**
Total PAH (16) (U = 1/2)	**6.66748 J**	**12.5591**	**13.75734 J**	**51.508 J**	**6.3808 J**	**1.2078 J**

Appendix A-2
Results for Surface Sediment Samples Upstream of the Site

Notes:
Bold = Detected result
J = Estimated value
N = Normal Field Sample FD = Field Duplicate
U = Compound analyzed, but not detected above detection limit
mg/kg = milligrams per kilogram
Totals are calculated as the sum of all detected results and half of the detection limit of undetected results (U=1/2).
Total LPAH (Low PAH) are the total of Naphthalene, Acenaphthylene, Acenaphthene, Fluorene, Phenanthrene, Anthracene, and 2-Methylnapthalene.
Total HPAH (High PAH) are the total of Fluoranthene, Pyrene, Benzo(a)anthracene, Chrysene, Benzofluoranthenes, Benzo(a)pyrene, Indeno(1,2,3-c,d)pyrene,

Total PAH are the total of Naphthalene, Acenaphthylene, Acenaphthene, Fluorene, Phenanthrene, Anthracene, Fluoranthene, Pyrene, Benzo(a)anthracene, Chrysene,
Benzofluoranthenes, Benzo(a)pyrene, Indeno(1,2,3-c,d)pyrene, Dibenzo(a,h)anthracene, and Benzo(g,h,i)perylene, and 2-Methylnapthalene.

Appendix A-3
Results for Subsurface Sediment Samples

Station Code	EF-001	EF-001	EF-001	EF-001	EF-001	EF-001	EF-001	EF-001	PB003	PB003	PB003	PB003
Sample ID	EF001-1SC041-N	EF001-1SC071-D	EF001-1SC071-N	EF001-1SC101-N	EF001-1SC131-N	EF001-1SC161-N	EF001-1SC191-N	EF001-1SC221-N	PB003-1SC041-N	PB003-1SC071-N	PB003-1SC101-N	PB003-1SC131-N
Sample Date	10/5/2006	10/5/2006	10/5/2006	10/5/2006	10/5/2006	10/5/2006	10/5/2006	10/5/2006	10/2/2006	10/2/2006	10/2/2006	10/2/2006
Sample Type	N	FD	N	N	N	N	N	N	N	N	N	N
X Coordinate	3201632.958	3201632.958	3201632.958	3201632.958	3201632.958	3201632.958	3201632.958	3201632.958	3202134.797	3202134.797	3202134.797	3202134.797
Y Coordinate	13831246.94	13831246.94	13831246.94	13831246.94	13831246.94	13831246.94	13831246.94	13831246.94	13836154.412	13836154.412	13836154.412	13836154.412
PCB Aroclors (mg/kg)												
Total PCB Aroclors (U = 1/2)	1.095	1.37	1.395	1.87	1.96	2.045	1.615	1.45	5.985	4.58	7.315	4.315
Polycyclic Aromatic Hydrocarbons (mg/kg)												
Total HPAH (9 of 16) (U = 1/2)	2.156	1.498	1.874	1.12	1.132	1.131	1.1403	1.59	6.918	11.453	24.766	9.899
Total LPAH (7 of 16) (U = 1/2)	0.31	0.239	0.315	0.254	0.373	0.667	0.865	0.816	2.256	3.56	10.1	5.09
Total PAH (16) (U = 1/2)	2.466	1.737	2.189	1.374	1.505	1.798	2.0053	2.406	9.174	15.013	34.866	14.989

Appendix A-3
Results for Subsurface Sediment Samples

Station Code	PB003	PB003	PB009	PB009	PB009	PB009	PB009	PB016	PB016	PB016	PB016	PB016
Sample ID	PB003-1SC161-N	PB003-1SC191-N	PB009-1SC031-N	PB009-1SC062-N	PB009-1SC093-N	PB009-1SC124-N	PB009-1SC135-N	PB016-1SC041-N	PB016-1SC071-N	PB016-1SC101-N	PB016-1SC121-N	PB016-1SC135-N
Sample Date	10/2/2006	10/2/2006	10/2/2006	10/2/2006	10/2/2006	10/2/2006	10/2/2006	10/3/2006	10/3/2006	10/3/2006	10/3/2006	10/3/2006
Sample Type	N	N	N	N	N	N	N	N	N	N	N	N
X Coordinate	3202134.797	3202134.797	3201846.046	3201846.046	3201846.046	3201846.046	3201846.046	3201172.392	3201172.392	3201172.392	3201172.392	3201172.392
Y Coordinate	13836154.412	13836154.412	13836186.465	13836186.465	13836186.465	13836186.465	13836186.465	13836105.369	13836105.369	13836105.369	13836105.369	13836105.369
PCB Aroclors (mg/kg)												
Total PCB Aroclors (U = 1/2)	2.91	2.055	16.65 J	18.25	42.85	35.2 J	10.2 J	21.9	66.05 J	81.15	90.0 J	0.963 J
Polycyclic Aromatic Hydrocarbons (mg/kg)												
Total HPAH (9 of 16) (U = 1/2)	11.572	3.247	9.9873	19.363	62.873 J	54.043 J	18.1133	17.726 J	392.11 J	93.513 J	409.79 J	0.4719 J
Total LPAH (7 of 16) (U = 1/2)	4.97	0.885	5.48	15.08	50.5	43.8	14.49	7	148.2	82.3	247.9	0.639
Total PAH (16) (U = 1/2)	16.542	4.132	15.4673	34.443	113.373 J	97.843 J	32.6033	24.726 J	540.31 J	175.813 J	657.69 J	1.1109 J

Appendix A-3
Results for Subsurface Sediment Samples

Station Code	PB018	PB022	PB022	PB022	PB022	PB022	PB022	PB022	PB030	PB030	PB036	PB036
Sample ID	PB018-1SC030-N	PB022-1SC041-N	PB022-1SC071-D	PB022-1SC071-N	PB022-1SC101-N	PB022-1SC131-N	PB022-1SC154-N	PB022-1SC180-N	PB030-1SC002-N	PB030-1SC011-N	PB036-1SC041-D	PB036-1SC041-N
Sample Date	10/3/2006	10/3/2006	10/3/2006	10/3/2006	10/3/2006	10/3/2006	10/3/2006	10/3/2006	10/4/2006	10/4/2006	10/4/2006	10/4/2006
Sample Type	N	N	FD	N	N	N	N	N	N	N	FD	N
X Coordinate	3201082.264	3201095.007	3201095.007	3201095.007	3201095.007	3201095.007	3201095.007	3201095.007	3201358.784	3201358.784	3201370.125	3201370.125
Y Coordinate	13835866.867	13835492.515	13835492.515	13835492.515	13835492.515	13835492.515	13835492.515	13835492.515	13834704.397	13834704.397	13834129.846	13834129.846
PCB Aroclors (mg/kg)												
Total PCB Aroclors (U = 1/2)	33.0 UJ	**53.6 J**	**53.6 J**	**58.5 J**	**107.5**	**111.5**	22.0 U	0.4 U	**1.91**	**1.335**	**87**	**81**
Polycyclic Aromatic Hydrocarbons (mg/kg)												
Total HPAH (9 of 16) (U = 1/2)	**131.75**	**53.137**	**58.037**	**54.352**	**104.141**	**348.39**	**14.02 J**	**0.1674 J**	**3.756**	**7.409**	**72.04**	**59.83**
Total LPAH (7 of 16) (U = 1/2)	**22.83**	**48.1**	**73.6**	**71.5**	**134.9**	**465**	**18.2**	**0.0903**	**1.421**	**2.427**	**216.6**	**204.3**
Total PAH (16) (U = 1/2)	**154.58**	**101.237**	**131.637**	**125.852**	**239.041**	**813.39**	**32.22 J**	**0.2577 J**	**5.177**	**9.836**	**288.64**	**264.13**

Appendix A-3
Results for Subsurface Sediment Samples

Station Code	PB036	PB036	PB036	PB036	PB036	PB036	PB036	PB042	PB042	PB042	PB042	PB042
Sample ID	PB036-1SC071-N	PB036-1SC101-N	PB036-1SC131-N	PB036-1SC161-N	PB036-1SC191-N	PB036-1SC200-N	PB036-1SC226-N	PB042-1SC041-N	PB042-1SC071-N	PB042-1SC101-N	PB042-1SC131-N	PB042-1SC158-N
Sample Date	10/4/2006	10/4/2006	10/4/2006	10/4/2006	10/4/2006	10/4/2006	10/4/2006	10/4/2006	10/4/2006	10/4/2006	10/4/2006	10/4/2006
Sample Type	N	N	N	N	N	N	N	N	N	N	N	N
X Coordinate	3201370.125	3201370.125	3201370.125	3201370.125	3201370.125	3201370.125	3201370.125	3201345.24	3201345.24	3201345.24	3201345.24	3201345.24
Y Coordinate	13834129.846	13834129.846	13834129.846	13834129.846	13834129.846	13834129.846	13834129.846	13833564.421	13833564.421	13833564.421	13833564.421	13833564.421
PCB Aroclors (mg/kg)												
Total PCB Aroclors (U = 1/2)	**69.65**	**129**	**162.5**	39.0 U	38.0 U	0.79 U	0.74 U	**172**	**294.5**	**230**	**14.72**	30.0 U
Polycyclic Aromatic Hydrocarbons (mg/kg)												
Total HPAH (9 of 16) (U = 1/2)	**25.354**	**32.872**	**52.08**	**40.805 J**	**72.86 J**	**17.14 J**	**1.33 J**	**14.644**	**62.58**	**162.21**	**48.177 J**	**16.569 J**
Total LPAH (7 of 16) (U = 1/2)	**45.1**	**68.7**	**120.1**	**119.8**	**332**	**89.6**	**3.13**	**32.1**	**199**	**654**	**167**	**36.7**
Total PAH (16) (U = 1/2)	**70.454**	**101.572**	**172.18**	**160.605 J**	**404.86 J**	**106.74 J**	**4.46 J**	**46.744**	**261.58**	**816.21**	**215.177 J**	**53.269 J**

Appendix A-3
Results for Subsurface Sediment Samples

Station Code	PB048	PB048	PB048	PB048	PB048	PB048	PB057	PB057	PB057	PB057	PB057	PB057
Sample ID	PB048-1SC041-N	PB048-1SC071-N	PB048-1SC101-N	PB048-1SC131-N	PB048-1SC161-N	PB048-1SC186-N	PB057-1SC041-N	PB057-1SC071-N	PB057-1SC101-N	PB057-1SC131-N	PB057-1SC177-N	PB057-1SC203-N
Sample Date	10/4/2006	10/4/2006	10/4/2006	10/4/2006	10/4/2006	10/4/2006	10/5/2006	10/5/2006	10/5/2006	10/5/2006	10/5/2006	10/5/2006
Sample Type	N	N	N	N	N	N	N	N	N	N	N	N
X Coordinate	3201486.842	3201486.842	3201486.842	3201486.842	3201486.842	3201486.842	3201467.145	3201467.145	3201467.145	3201467.145	3201467.145	3201467.145
Y Coordinate	13832966.961	13832966.961	13832966.961	13832966.961	13832966.961	13832966.961	13832096.911	13832096.911	13832096.911	13832096.911	13832096.911	13832096.911
PCB Aroclors (mg/kg)												
Total PCB Aroclors (U = 1/2)	**86.0 J**	**238.5**	**149.5**	**8.085**	**6.27**	0.32 UJ	**84**	**122.5**	**476**	**281**	**76.2**	**0.91**
Polycyclic Aromatic Hydrocarbons (mg/kg)												
Total HPAH (9 of 16) (U = 1/2)	**13.044**	**141.94**	**264.52**	**78.51**	**107.04**	**3.682**	**16.708**	**52.869 J**	**233.55**	**307.9**	**101.5**	**1.3872**
Total LPAH (7 of 16) (U = 1/2)	**18.8**	**470**	**998**	**233**	**332**	**12.63**	**68.48**	**197.3**	**827**	**1458**	**457**	**7.64**
Total PAH (16) (U = 1/2)	**31.844**	**611.94**	**1262.52**	**311.51**	**439.04**	**16.312**	**85.188**	**250.169 J**	**1060.55**	**1765.9**	**558.5**	**9.0272**

Appendix A-3
Results for Subsurface Sediment Samples

Station Code	PB063	PB063	PB063	PB073	PB073	PB077	PB084
Sample ID	PB063-1SC041-N	PB063-1SC074-N	PB063-1SC084-N	PB073-1SC034-N	PB073-1SC042-N	PB077-1SS007-N	PB084-1SS002-N
Sample Date	10/5/2006	10/5/2006	10/5/2006	10/5/2006	10/5/2006	10/5/2006	10/6/2006
Sample Type	N	N	N	N	N	N	N
X Coordinate	3201536.273	3201536.273	3201536.273	3201037.34	3201037.34	3200738.387	3200707.36
Y Coordinate	13831339.735	13831339.735	13831339.735	13830742.28	13830742.28	13830380.106	13829634.22
PCB Aroclors (mg/kg)							
Total PCB Aroclors (U = 1/2)	**57.4**	**86.6**	**0.7 J**	**34.2 J**	**0.74 J**	0.28 U	**4.785**
Polycyclic Aromatic Hydrocarbons (mg/kg)							
Total HPAH (9 of 16) (U = 1/2)	**10.053**	**7.891 J**	**9.41**	**26.76**	**0.1452 J**	**0.00833 J**	**5.729**
Total LPAH (7 of 16) (U = 1/2)	**18.33**	**45.04**	**1.4368 J**	**39**	**0.1785**	**0.00808 J**	**0.583**
Total PAH (16) (U = 1/2)	**28.383**	**52.931 J**	**10.8468 J**	**65.76**	**0.3237 J**	**0.01641 J**	**6.312**

Appendix A-3
Results for Subsurface Sediment Samples

Notes:
Bold = Detected result
J = Estimated value
N = Normal Field Sample FD = Field Duplicate
U = Compound analyzed, but not detected above detection limit
UJ = Compound analyzed, but not detected above estimated detection limit
mg/kg = milligrams per kilogram
Totals are calculated as the sum of all detected results and half of the **detection limit** of undetected results (U=1/2).
Total LPAH (Low PAH) are the total of Naphthalene, Acenaphthylene, Acenaphthene, Fluorene, Phenanthrene, Anthracene, and 2-Methylnapthalene.
Total HPAH (High PAH) are the total of Fluoranthene, Pyrene, Benzo(a)anthracene, Chrysene, Benzofluoranthenes, Benzo(a)pyrene, Indeno(1,2,3-c,d)pyrene, Dibenzo(a,h)anthracene and Benzo(g,h,i)perylene.
Total PAH are the total of Naphthalene, Acenaphthylene, Acenaphthene, Fluorene, Phenanthrene, Anthracene, Fluoranthene, Pyrene, Benzo(a)anthracene, Chrysene, Benzofluoranthenes, Benzo(a)pyrene, Indeno(1,2,3-c,d)pyrene, Dibenzo(a,h)anthracene, and Benzo(g,h,i)perylene, and 2-Methylnapthalene.

Appendix A-4
Results for Porewater Samples

Station Code	PB006A	PB006B	PB023	PB024	PB036	PB044	PB046	PB052	PB053	PB059
Sample ID	PB06A-IPW011-N-PW	PB06B-IPW011-N-PW	PB023-IPW011-N PW	PB024-IPW011-N PW	PB036-IPW011-N PW	PB044-IPW011-N PW	PB046-IPW011-N PW	PB052-IPW011-N-PW	PB053-IPW011-N-PW	PB059-IPW011-N-PW
Sample Date	8/9/2007	8/9/2007	8/3/2007	8/4/2007	8/6/2007	8/6/2007	8/7/2007	8/7/2007	8/8/2007	8/8/2007
Sample Type	N	N	N	N	N	N	N	N	N	N
X Coordinate	3202093.747	3202102.439	3201248.237	3201156.027	3201370.125	3201558.242	3201463.088	3201291.129	3201424.79	3201568.99
Y Coordinate	13836310.6	13836108.912	13835348.818	13835258.65	13834129.846	13833323.071	13833149.15	13832577.162	13832460.56	13831885.676
Metals, Dissolved (porewater) (µg/L)										
Lead	0.064 U	0.619 U	0.225 U	0.121 U	0.335 U	0.083 U	0.173 U	0.13 U	0.277 U	0.175 U
Semivolatile Organic Compounds (µg/L)										
Bis(2-ethylhexyl)phthalate	**1**	**1.6**	**6.2**	**84 J**	**180 J**	**1.2**	**140**	**2.6**	**49**	**46**
PCB Congeners (porewater) (µg/L)										
Total Decachlorobiphenyl homologs (U = 1/2)	**0.137**	**0.702**	**1.76**	**0.771 J**	**87**	**0.0716**	**0.0173**	**0.0366**	**0.0481**	**0.0131**
Total Dichlorobiphenyl homologs (U = 1/2)	**0.01099 J**	**0.02633 J**	**0.08773**	**0.03848**	**203.3**	**0.01732 J**	**0.03382 J**	**0.12273 J**	**0.20371**	**0.34539 J**
Total Heptachlorobiphenyl homologs (U = 1/2)	**0.08198 J**	**0.532 J**	**0.47492 J**	**0.27169 J**	**124.22 J**	**0.25423 J**	**0.21006 J**	**0.30022 J**	**1.2032 J**	**1.34109 J**
Total Hexachlorobiphenyl homologs (U = 1/2)	**0.1418 J**	**0.57768 J**	**0.7872 J**	**0.53627 J**	**237.692 J**	**0.47824 J**	**0.2683 J**	**0.7199 J**	**1.37933 J**	**1.84864 J**
Total Monochlorobiphenyl homologs (U = 1/2)	0.004 UJ	**0.00099 J**	**0.001894 J**	**0.0015**	**26.824**	0.004 UJ	**0.005664 J**	**0.00549 J**	**0.00983**	**0.006505 J**
Total Nonachlorobiphenyl homologs (U = 1/2)	**0.00858 J**	**0.03771 J**	**0.0716**	**0.03778**	**4.029 J**	**0.00887 J**	**0.02311**	**0.00826 J**	**0.03643 J**	**0.01664 J**
Total Octachlorobiphenyl homologs (U = 1/2)	**0.03902 J**	**0.09012 J**	**0.11223 J**	**0.11448 J**	**25.829 J**	**0.04987 J**	**0.07535 J**	**0.04507 J**	**0.23563 J**	**0.20902 J**
Total Pentachlorobiphenyl homologs (U = 1/2)	**0.31611 J**	**1.08007 J**	**3.01439 J**	**2.51009 J**	**1324.591 J**	**1.40819 J**	**0.55284 J**	**4.15055 J**	**3.19453 J**	**6.0803 J**
Total Tetrachlorobiphenyl homologs (U = 1/2)	**0.59216 J**	**2.20006 J**	**6.2216 J**	**4.47676 J**	**3037.894 J**	**2.42973 J**	**0.69625 J**	**10.01838 J**	**7.45814 J**	**16.07628 J**
Total Trichlorobiphenyl homologs (U = 1/2)	**0.22819 J**	**0.63813**	**1.94387**	**1.26209 J**	**2039.332 J**	**0.78676 J**	**0.32395**	**3.15233**	**3.09291**	**6.1748**
Total PCB Congener (U = 1/2)	**1.55888 J**	**5.88509 J**	**14.47543 J**	**10.02013 J**	**7110.711 J**	**5.50786 J**	**2.20664 J**	**18.55953 J**	**16.86181 J**	**32.11177 J**
Polycyclic Aromatic Hydrocarbons (porewater) (µg/L)										
Total HPAH (9 of 16) (U = 1/2)	**1.071 J**	**3.819**	**5.001 J**	**2600.5**	**5720**	**2.239**	**32.72**	**2.556**	**7.83**	**3.234 J**
Total LPAH (7 of 16) (U = 1/2)	**0.906**	**0.869**	**3.91**	**6560**	**13900**	**1.131**	**12.66**	**1.366**	**4.268**	**3.19**
Total PAH (16) (U = 1/2)	**1.977 J**	**4.688**	**8.911 J**	**9160.5**	**19620**	**3.37**	**45.38**	**3.922**	**12.098**	**6.424 J**

Notes:

Bold = Detected result

J = Estimated value
U = Compound analyzed, but not detected above detection limit
UJ = Compound analyzed, but not detected above estimated detection limit

µg/L = micrograms per liter

Totals are calculated as the sum of all detected results and half of the **detection limit** of undetected results (U=1/2).
Total LPAH (Low PAH) are the total of Naphthalene, Acenaphthylene, Acenaphthene, Fluorene, Phenanthrene, Anthracene, and 2-Methylnapthalene
Total HPAH (High PAH) are the total of Fluoranthene, Pyrene, Benzo(a)anthracene, Chrysene, Benzofluoranthenes, Benzo(a)pyrene, Indeno(1,2,3-c,d)pyrene, Dibenzo(a,h)anthracene and Benzo(g,h,i)perylene
Total PAH are the total of Naphthalene, Acenaphthylene, Acenaphthene, Fluorene, Phenanthrene, Anthracene, Fluoranthene, Pyrene, Benzo(a)anthracene, Chrysene, Benzofluoranthenes, Benzo(a)pyrene, Indeno(1,2,3-c,d)pyrene, Dibenzo(a,h)anthracene and Benzo(g,h,i)perylene, and 2-Methylnapthalene

N = Normal Field Sample

Appendix A-5
Results for Surface Water Samples

Station Code	EF006	EF006	HSC14	HSC14	HSC14	HSC14	PB006_A	PB006_A
Sample ID	EF006-1SWMID-091104-N	EF006-1SWMID-091105-N	HSC14-1SWMID-091104-N	HSC14-1SWMID-091105-N	HSC14-1SWNBT-091104-N	HSC14-1SWNBT-091105-N	PB006-1SWMID-091104-N	PB006-1SWMID-091105-N
Sample Date	11/4/2009	11/5/2009	11/4/2009	11/5/2009	11/4/2009	11/5/2009	11/4/2009	11/5/2009
Sample Type	N	N	N	N	N	N	N	N
X Coordinate	3201918.0731	3201918.0731	3201202.6970	3201202.6970	3201202.6970	3201202.6970	3202137.4168	3202137.4168
Y Coordinate	13831080.4856	13831080.4856	13836966.5341	13836966.5341	13836966.5341	13836966.5341	13836272.1183	13836272.1183
PCB Congeners (µg/L)								
Total Decachlorobiphenyl homologs (U = 1/2)	**0.000044 J**	**0.000108**	**0.000071**	**0.00013**	**0.000128**	**0.000146**	**0.00814 J**	**0.00797 J**
Total Dichlorobiphenyl homologs (U = 1/2)	**0.000082 J**	**0.000063 J**	**0.00018 J**	**0.00014 J**	**0.00018 J**	**0.00011 J**	**0.001062 J**	**0.000823 J**
Total Heptachlorobiphenyl homologs (U = 1/2)	**0.00019 J**	**0.00016 J**	**0.00035 J**	**0.00026 J**	**0.00029 J**	**0.00025 J**	**0.001986 J**	**0.00219 J**
Total Hexachlorobiphenyl homologs (U = 1/2)	**0.00047 J**	**0.00041 J**	**0.0007 J**	**0.0005 J**	**0.00064 J**	**0.00051 J**	**0.00592 J**	**0.00629 J**
Total Monochlorobiphenyl homologs (U = 1/2)	0.00001 U	**0.000011 J**	**0.00001 J**	**0.00001 J**	**0.00002 J**	**0.00002 J**	**0.000024 J**	**0.000019 J**
Total Nonachlorobiphenyl homologs (U = 1/2)	0.00001 UJ	0.000008 U	**0.00002 J**	0.00001 U	0.00001 U	**0.00002 J**	**0.000503 J**	**0.000452 J**
Total Octachlorobiphenyl homologs (U = 1/2)	**0.00006 J**	**0.000048 J**	**0.0001 J**	**0.00007 J**	**0.00009 J**	**0.00008 J**	**0.00054 J**	**0.00052 J**
Total Pentachlorobiphenyl homologs (U = 1/2)	**0.00069 J**	**0.000616 J**	**0.00085 J**	**0.00066 J**	**0.00093 J**	**0.00067 J**	**0.0194 J**	**0.02123**
Total Tetrachlorobiphenyl homologs (U = 1/2)	**0.00085 J**	**0.00086 J**	**0.00106 J**	**0.00093 J**	**0.00129 J**	**0.00083 J**	**0.04226 J**	**0.04737 J**
Total Trichlorobiphenyl homologs (U = 1/2)	**0.00034 J**	**0.000354 J**	**0.00064 J**	**0.00047 J**	**0.00069 J**	**0.00036 J**	**0.017694 J**	**0.01616 J**
Total PCB Congener (U = 1/2)	**0.00276 J**	**0.00265 J**	**0.00399 J**	**0.00318 J**	**0.00426 J**	**0.00299 J**	**0.09753 J**	**0.10304 J**

Station Code	PB006_A	PB006_A	PB031	PB031	PB031	PB031	PB059_A	PB059_A
Sample ID	PB006-1SWNBT-091104-N	PB006-1SWNBT-091105-N	PB031-1SWMID-091104-N	PB031-1SWMID-091105-N	PB031-1SWNBT-091104-N	PB031-1SWNBT-091105-N	PB059-1SWMID-091104-N	PB059-1SWMID-091105-N
Sample Date	11/4/2009	11/5/2009	11/4/2009	11/5/2009	11/4/2009	11/5/2009	11/4/2009	11/5/2009
Sample Type	N	N	N	N	N	N	N	N
X Coordinate	3202137.4168	3202137.4168	3201366.8205	3201366.8205	3201366.8205	3201366.8205	3201646.6295	3201646.6295
Y Coordinate	13836272.1183	13836272.1183	13834640.6333	13834640.6333	13834640.6333	13834640.6333	13831831.4316	13831831.4316
PCB Congeners (µg/L)								
Total Decachlorobiphenyl homologs (U = 1/2)	**0.00952 J**	**0.0076 J**	**0.0021**	**0.00472**	**0.00231 J**	**0.00352 J**	**0.000542 J**	**0.000163 J**
Total Dichlorobiphenyl homologs (U = 1/2)	**0.001745 J**	**0.00098 J**	**0.003674 J**	**0.00173 J**	**0.003761 J**	**0.00221 J**	**0.00831 J**	**0.0029 J**
Total Heptachlorobiphenyl homologs (U = 1/2)	**0.00336 J**	**0.00228 J**	**0.002889 J**	**0.00266 J**	**0.00302 J**	**0.00321 J**	**0.00401 J**	**0.00106 J**
Total Hexachlorobiphenyl homologs (U = 1/2)	**0.01058 J**	**0.00688 J**	**0.01057 J**	**0.00834**	**0.01053 J**	**0.0104 J**	**0.01716 J**	**0.00464 J**
Total Monochlorobiphenyl homologs (U = 1/2)	**0.00004 J**	**0.00002 J**	**0.000056 J**	**0.00003 J**	**0.00008 J**	**0.00003 J**	**0.00021 J**	**0.00008 J**
Total Nonachlorobiphenyl homologs (U = 1/2)	**0.000609 J**	**0.00048**	**0.000256**	**0.00038**	**0.000241 J**	**0.000321 J**	**0.00016 J**	**0.00004 J**
Total Octachlorobiphenyl homologs (U = 1/2)	**0.00085 J**	**0.0006 J**	**0.00067 J**	**0.000637 J**	**0.00061 J**	**0.00072 J**	**0.00082 J**	**0.00023 J**
Total Pentachlorobiphenyl homologs (U = 1/2)	**0.03656 J**	**0.02327**	**0.04534 J**	**0.03121 J**	**0.0456 J**	**0.04148 J**	**0.08787 J**	**0.02453 J**
Total Tetrachlorobiphenyl homologs (U = 1/2)	**0.07844 J**	**0.05134 J**	**0.11496**	**0.07504**	**0.10923**	**0.09641 J**	**0.21065 J**	**0.06803 J**
Total Trichlorobiphenyl homologs (U = 1/2)	**0.03182 J**	**0.01851**	**0.053129 J**	**0.03082**	**0.054805**	**0.0388 J**	**0.10125 J**	**0.03331 J**
Total PCB Congener (U = 1/2)	**0.17353 J**	**0.11197 J**	**0.23364 J**	**0.15556 J**	**0.23018 J**	**0.1971 J**	**0.43098 J**	**0.135 J**

Appendix A-5
Results for Surface Water Samples

Station Code	PB066_B	PB076	PB076	PB076	PB076	PB080	PB082.1
Sample ID	PB066-1SWMID-20110808-N	PB076-1SWMID-091104-N	PB076-1SWMID-091105-N	PB076-1SWNBT-091104-N	PB076-1SWNBT-091105-N	PBUC053D-1SWMID-20110808-N	PBUC053U-1SWMID-20110808-N
Sample Date	8/8/2011	11/4/2009	11/5/2009	11/4/2009	11/5/2009	8/8/2011	8/8/2011
Sample Type	N	N	N	N	N	N	N
X Coordinate	3201384.326	3200819.7773	3200819.7773	3200819.7773	3200819.7773	3200769.755	3200777.403
Y Coordinate	13831305.66	13830437.4855	13830437.4855	13830437.4855	13830437.4855	13830051.11	13829942.54
PCB Congeners (µg/L)							
Total Decachlorobiphenyl homologs (U = 1/2)	**0.000353**	**0.000092 J**	**0.000245 J**	**0.000144 J**	**0.000685 J**	**0.000965**	**0.000267**
Total Dichlorobiphenyl homologs (U = 1/2)	**0.00251 J**	**0.0014 J**	**0.00121 J**	**0.001804 J**	**0.001423 J**	**0.00298 J**	**0.002073**
Total Heptachlorobiphenyl homologs (U = 1/2)	**0.00056 J**	**0.00105 J**	**0.00057 J**	**0.00165 J**	**0.00109 J**	**0.000925 J**	**0.000433 J**
Total Hexachlorobiphenyl homologs (U = 1/2)	**0.002391 J**	**0.00397 J**	**0.00245 J**	**0.00628 J**	**0.00454 J**	**0.003904 J**	**0.00193 J**
Total Monochlorobiphenyl homologs (U = 1/2)	**0.000056**	**0.000061 J**	**0.00005 J**	**0.000073 J**	**0.00006 J**	**0.000058**	**0.000065**
Total Nonachlorobiphenyl homologs (U = 1/2)	**0.000036 J**	**0.00004 J**	0.00001 UJ	**0.000062 J**	**0.000049 J**	**0.000065 J**	**0.000031 J**
Total Octachlorobiphenyl homologs (U = 1/2)	**0.000117 J**	**0.00022 J**	**0.000106 J**	**0.00032 J**	**0.00022 J**	**0.000206 J**	**0.000093 J**
Total Pentachlorobiphenyl homologs (U = 1/2)	**0.01398 J**	**0.01782**	**0.01226 J**	**0.02724 J**	**0.02149 J**	**0.02186 J**	**0.01103**
Total Tetrachlorobiphenyl homologs (U = 1/2)	**0.04928 J**	**0.03975 J**	**0.02907 J**	**0.05635 J**	**0.04676 J**	**0.07117 J**	**0.04032 J**
Total Trichlorobiphenyl homologs (U = 1/2)	**0.031216 J**	**0.01662 J**	**0.01291 J**	**0.02332 J**	**0.017702 J**	**0.04112 J**	**0.023672 J**
Total PCB Congener (U = 1/2)	**0.10049 J**	**0.08102 J**	**0.05888 J**	**0.11726 J**	**0.09401 J**	**0.14325 J**	**0.07992 J**

Appendix A-5
Results for Surface Water Samples

Station Code	PB101_C	PB119_A	PB119_A
Sample ID	PB101-1SWMID-20110808-N	PB119-1SWMID-091104-N	PB119-1SWMID-091105-N
Sample Date	8/8/2011	11/4/2009	11/5/2009
Sample Type	N	N	N
X Coordinate	3201307.665	3201525.3929	3201525.3929
Y Coordinate	13828208.48	13826332.9975	13826332.9975
PCB Congeners (µg/L)			
Total Decachlorobiphenyl homologs (U = 1/2)	0.000009 U	0.000012 U	**0.000303 J**
Total Dichlorobiphenyl homologs (U = 1/2)	**0.000143 J**	**0.000104 J**	**0.000098 J**
Total Heptachlorobiphenyl homologs (U = 1/2)	**0.000068 J**	**0.000139 J**	**0.00014 J**
Total Hexachlorobiphenyl homologs (U = 1/2)	**0.00019 J**	**0.00025 J**	**0.000276 J**
Total Monochlorobiphenyl homologs (U = 1/2)	**0.00001 J**	**0.000018 J**	**0.000021 J**
Total Nonachlorobiphenyl homologs (U = 1/2)	**0.000007 J**	0.000012 U	0.000012 UJ
Total Octachlorobiphenyl homologs (U = 1/2)	**0.00002 J**	0.000024 U	0.000024 UJ
Total Pentachlorobiphenyl homologs (U = 1/2)	**0.000936 J**	**0.0003 J**	**0.00033 J**
Total Tetrachlorobiphenyl homologs (U = 1/2)	**0.00321 J**	**0.00024 J**	**0.00027 J**
Total Trichlorobiphenyl homologs (U = 1/2)	**0.00106 J**	**0.00012 J**	**0.00015 J**
Total PCB Congener (U = 1/2)	**0.00565 J**	**0.00128 J**	**0.00168 J**

Appendix A-5
Results for Surface Water Samples

Notes:
Bold = Detected result
J = Estimated value
N = Normal Field Sample
U = Compound analyzed, but not detected above detection limit
UJ = Compound analyzed, but not detected above estimated detection limit
µg/l = micrograms per liter
Totals are calculated as the sum of all detected results and half of the **detection limit** of undetected results (U=1/2).

Appendix A-6
Results for Sediment Trap Samples

Station Code	EF-001	EF-001	EF-001	EF-001	EF-001	PB077	PB077	PB077	PB077	PB077	PB077
Sample ID	EF001-1ST-N-071022	EF001-1ST-N-071210	EF001-2ST-N	EF001-4ST-N	EF001-5ST-N	PB077-1T-N	PB077-2ST-N	PB077-3ST-N	PB077-4ST-N	PB077-5ST-N	PB077-6ST-N
Sample Date	10/22/2007	12/10/2007	1/22/2008	3/25/2008	4/30/2008	9/11/2007	10/22/2007	12/10/2007	1/22/2008	3/25/2008	4/30/2008
Sample Type	N	N	N	N	N	N	N	N	N	N	N
X Coordinate	3201632.958	3201632.958	3201632.958	3201632.958	3201632.958	3200738.387	3200738.387	3200738.387	3200738.387	3200738.387	3200738.387
Y Coordinate	13831246.94	13831246.94	13831246.94	13831246.94	13831246.94	13830380.106	13830380.106	13830380.106	13830380.106	13830380.106	13830380.106
Metals (mg/kg)											
Lead	38.8	35.4	22.9 J	24	23.2	30.7	50.2	42.6	47.1 J	31.1	45.9
Semivolatile Organics (µg/kg)											
bis(2-Ethylhexyl)phthalate	520 J	560 J	170 J	290 J	580 J	2000 J	2600	2700 J	2100 J	1200	1800 J
PCB Congeners (mg/kg)											
Total Decachlorobiphenyl homologs (U = 1/2)	0.00917	0.00124	0.00433	0.00574	0.000181 J	0.000141	0.00661	0.0114	0.0012	0.00237	0.000246
Total Dichlorobiphenyl homologs (U = 1/2)	0.009384 J	0.002398 J	0.00611	0.002893 J	0.001179 J	0.00258	0.023857	0.03219	0.01093 J	0.01634 J	0.002562 J
Total Heptachlorobiphenyl homologs (U = 1/2)	0.01749 J	0.004644 J	0.01154 J	0.0072 J	0.00223 J	0.008739 J	0.04316 J	0.07022 J	0.02163 J	0.02101 J	0.00416 J
Total Hexachlorobiphenyl homologs (U = 1/2)	0.044615 J	0.01017 J	0.03073 J	0.02131 J	0.00472 J	0.02781 J	0.10728 J	0.19239 J	0.09205 J	0.038889 J	0.01512 J
Total Monochlorobiphenyl homologs (U = 1/2)	0.000212 J	0.000094 J	0.00012 J	0.000059 J	0.000078 J	0.000128 J	0.0005 J	0.000596 J	0.000257 J	0.00065 J	0.000075 J
Total Nonachlorobiphenyl homologs (U = 1/2)	0.000715 J	0.000127 J	0.000477 J	0.000334 J	0.000025 J	0.000172 J	0.001399 J	0.001995 J	0.000437 J	0.000995 J	0.000087 J
Total Octachlorobiphenyl homologs (U = 1/2)	0.003718 J	0.00088 J	0.002509 J	0.00153 J	0.00041 J	0.00163 J	0.00988 J	0.014902 J	0.00423 J	0.008065 J	0.00122 J
Total Pentachlorobiphenyl homologs (U = 1/2)	0.21236 J	0.03995 J	0.12379 J	0.0717 J	0.01036 J	0.13566 J	0.49782 J	0.8499 J	0.58226 J	0.06282 J	0.06591 J
Total Tetrachlorobiphenyl homologs (U = 1/2)	0.57556 J	0.08948 J	0.30542 J	0.16079 J	0.02019 J	0.286745 J	1.10717 J	1.771905 J	1.24425 J	0.00792	0.13822 J
Total Trichlorobiphenyl homologs (U = 1/2)	0.226235 J	0.038557 J	0.09908 J	0.059598 J	0.007092 J	0.07516	0.594643 J	0.770128 J	0.18765 J	0.01491 J	0.04431 J
Total PCB Congener (U = 1/2)	1.09945 J	0.18755 J	0.5841 J	0.33117 J	0.04647 J	0.53876 J	2.39232 J	3.71562 J	2.14489 J	0.17397 J	0.2719 J
Polycyclic Aromatic Hydrocarbons (mg/kg)											
Total HPAH (9 of 16) (U = 1/2)	1.541	13.13	1.362 J	0.856 J	7.17	7.97	5.97	6.73 J	4.496 J	5.288	6.24
Total LPAH (7 of 16) (U = 1/2)	0.1572	2.804 J	0.1115 J	0.0742	1.681	3.51	0.602	0.955 J	0.541 J	0.542	0.831
Total PAH (16) (U = 1/2)	1.6982	15.934 J	1.4735 J	0.9302 J	8.851	11.48	6.572	7.685 J	5.037 J	5.83	7.071

Notes:
Bold = Detected result
N = Normal Field Sample
J = Estimated value
mg/kg = milligrams per kilogram
µg/kg = microgram per kilogram
Totals are calculated as the sum of all detected results and half of the **detection limit** of undetected results (U=1/2).
Total LPAH (Low PAH) are the total of Naphthalene, Acenaphthylene, Acenaphthene, Fluorene, Phenanthrene, Anthracene, and 2-Methylnapthalene.
Total HPAH (High PAH) are the total of Fluoranthene, Pyrene, Benzo(a)anthracene, Chrysene, Benzofluoranthenes, Benzo(a)pyrene, Indeno(1,2,3-c,d)pyrene, Dibenzo(a,h)anthracene, and Benzo(g,h,i)perylene.
Total PAH are the total of Naphthalene, Acenaphthylene, Acenaphthene, Fluorene, Phenanthrene, Anthracene, Fluoranthene, Pyrene, Benzo(a)anthracene, Chrysene, Benzofluoranthenes, Benzo(a)pyrene, Indeno(1,2,3-c,d)pyrene, Dibenzo(a,h)anthracene, and Benzo(g,h,i)perylene, and 2-Methylnapthalene.

Appendix A-7
Results for Edible Tissue Samples

Station Code	**PB001.3_B**	**PB007.4**	**PB007.4**	**PB007.4**	**PB007.4**	**PB011_C**
Sample ID	**PB01-I-C-BCR-E-009-20111004**	**PB01-F-C-HHC-E-024-20111002**	**PB01-F-C-HHC-E-025-20111002**	**PB01-F-C-HHC-E-026-20111002**	**PB01-F-C-HHC-E-027-20111002**	**PB01-F-C-HHC-E-028-20111003**
Sample Date	**10/3/2011**	**10/2/2011**	**10/2/2011**	**10/2/2011**	**10/2/2011**	**10/3/2011**
Sample Type	**N**	**N**	**N**	**N**	**N**	**N**
X Coordinate	**3202727.02**	**3202001.75**	**3202001.75**	**3202001.75**	**3202001.75**	**3201723.74**
Y Coordinate	**13836477.06**	**13836322.24**	**13836322.24**	**13836322.24**	**13836322.24**	**13836209.92**
Scientific Name	**Callinectes sapidus**	**Ariopsis felis**	**Ariopsis felis**	**Ariopsis felis**	**Ariopsis felis**	**Ariopsis felis**
Common Name	**Blue crab**	**Hardhead catfish**	**Hardhead catfish**	**Hardhead catfish**	**Hardhead catfish**	**Hardhead catfish**
PCB Congeners (µg/kg)						
Total PCB Congener (U = 1/2)	**41.24482 J**	**877.67061 J**	**1985.66447 J**	**958.92855 J**	**1383.77913 J**	**424.93037 J**
PCB Congeners (ng/kg)						
Total PCB Congener TEQ 2005 (Mammal) (U = 1/2)*	**1.4 J**	**15.8 J**	**27.75 J**	**14.39953**	**24.1 J**	**6.7 J**

Appendix A-7
Results for Edible Tissue Samples

Station Code	PB011_C	PB011_C	PB015_C	PB016.1	PB016.1	PB016.1
Sample ID	PB01-F-C-HHC-E-029-20111003	PB01-I-C-BCR-E-008-20111004	PB01-I-C-BCR-E-006-20111001	PB01-F-C-HHC-E-005-20110930	PB01-F-C-HHC-E-011-20110930	PB01-F-C-HHC-E-019-20110930
Sample Date	10/3/2011	10/3/2011	9/30/2011	9/30/2011	9/30/2011	9/30/2011
Sample Type	N	N	N	N	N	N
X Coordinate	3201723.74	3201723.74	3201217.73	3201112.34	3201112.34	3201112.34
Y Coordinate	13836209.92	13836209.92	13836206.51	13836190.45	13836190.45	13836190.45
Scientific Name	Ariopsis felis	Callinectes sapidus	Callinectes sapidus	Ariopsis felis	Ariopsis felis	Ariopsis felis
Common Name	Hardhead catfish	Blue crab	Blue crab	Hardhead catfish	Hardhead catfish	Hardhead catfish
PCB Congeners (µg/kg)						
Total PCB Congener (U = 1/2)	**1567.64705 J**	**116.31948 J**	**199.6045 J**	**658.3353 J**	**187.0432 J**	**1921.75976 J**
PCB Congeners (ng/kg)						
Total PCB Congener TEQ 2005 (Mammal) (U = 1/2)*	**31.1 J**	**4.1 J**	**7.22 J**	**7.5 J**	**3.3 J**	**31.7 J**

Appendix A-7
Results for Edible Tissue Samples

Station Code	PB018_C	PB018_C	PB018_C	PB018_C	PB022_C	PB022_C
Sample ID	PB01-F-C-HHC-E-001-20110929	PB01-F-C-HHC-E-002-20110929	PB01-F-C-HHC-E-003-20110929	PB01-I-C-BCR-E-002-20111001	PB01-F-C-HHC-E-004-20110930	PB01-I-C-BCR-E-001-20111001
Sample Date	9/29/2011	9/29/2011	9/29/2011	9/30/2011	9/30/2011	9/30/2011
Sample Type	N	N	N	N	N	N
X Coordinate	3201150.93	3201150.93	3201150.93	3201150.93	3201144.79	3201144.79
Y Coordinate	13835674.82	13835674.82	13835674.82	13835674.82	13835440.46	13835440.46
Scientific Name	Ariopsis felis	Ariopsis felis	Ariopsis felis	Callinectes sapidus	Ariopsis felis	Callinectes sapidus
Common Name	Hardhead catfish	Hardhead catfish	Hardhead catfish	Blue crab	Hardhead catfish	Blue crab
PCB Congeners (µg/kg)						
Total PCB Congener (U = 1/2)	1402.33945 J	1294.13458 J	555.60674 J	376.62663 J	1668.14985 J	48.12964 J
PCB Congeners (ng/kg)						
Total PCB Congener TEQ 2005 (Mammal) (U = 1/2)*	24.1	22.8	8.9 J	8.07 J	25.3	2.13 J

Appendix A-7
Results for Edible Tissue Samples

Station Code	PB024_C	PB028_B	PB028_B	PB028_B	PB028_B	PB032.2
Sample ID	PB01-I-C-BCR-E-004-20111001	PB02-F-C-HHC-E-001-20110929	PB02-F-C-HHC-E-003-20110929	PB02-I-C-BCR-E-001-20110930	PB02-I-C-BCR-E-002-20110930	PB02-F-C-HHC-E-004-20110929
Sample Date	9/30/2011	9/29/2011	9/29/2011	9/30/2011	9/30/2011	9/29/2011
Sample Type	N	N	N	N	N	N
X Coordinate	3201156.66	3201357.46	3201357.46	3201357.46	3201357.46	3201406.82
Y Coordinate	13835154.20	13834829.23	13834829.23	13834829.23	13834829.23	13834407.04
Scientific Name	Callinectes sapidus	Ariopsis felis	Ariopsis felis	Callinectes sapidus	Callinectes sapidus	Ariopsis felis
Common Name	Blue crab	Hardhead catfish	Hardhead catfish	Blue crab	Blue crab	Hardhead catfish
PCB Congeners (µg/kg)						
Total PCB Congener (U = 1/2)	**43.06537 J**	**1832.76508 J**	**1204.6475 J**	**104.69543 J**	**192.8242 J**	**2158.90022 J**
PCB Congeners (ng/kg)						
Total PCB Congener TEQ 2005 (Mammal) (U = 1/2)*	**1.12 J**	**40.6 J**	**25.4 J**	**3.22 J**	**5.37**	**39.9 J**

Appendix A-7
Results for Edible Tissue Samples

Station Code	PB032.2	PB032.2	PB032_B	PB032_B	PB032_B	PB032_B
Sample ID	PB02-F-C-HHC-E-005-20110929	PB02-F-C-HHC-E-006-20110929	PB02-F-C-HHC-E-014-20111001	PB02-F-C-HHC-E-015-20111001	PB02-F-C-HHC-E-016-20111001	PB02-I-C-BCR-E-007-20111002
Sample Date	9/29/2011	9/29/2011	10/1/2011	10/1/2011	10/1/2011	10/2/2011
Sample Type	N	N	N	N	N	N
X Coordinate	3201406.82	3201406.82	3201334.62	3201334.62	3201334.62	3201334.62
Y Coordinate	13834407.04	13834407.04	13834509.20	13834509.20	13834509.20	13834509.20
Scientific Name	Ariopsis felis	Ariopsis felis	Ariopsis felis	Ariopsis felis	Ariopsis felis	Callinectes sapidus
Common Name	Hardhead catfish	Hardhead catfish	Hardhead catfish	Hardhead catfish	Hardhead catfish	Blue crab
PCB Congeners (µg/kg)						
Total PCB Congener (U = 1/2)	610.90035 J	2409.74141 J	2081.42917 J	1210.50791 J	1985.46075 J	52.47021 J
PCB Congeners (ng/kg)						
Total PCB Congener TEQ 2005 (Mammal) (U = 1/2)*	11.0 J	39.3	33.5 J	19.1 J	29.62	1.18 J

Appendix A-7
Results for Edible Tissue Samples

Station Code	PB034_C	PB037.3	PB037.3	PB037_B	PB047.2_B	PB047.2_B
Sample ID	PB02-I-C-BCR-E-011-20111005	PB02-F-C-HHC-E-019-20111004	PB02-F-C-HHC-E-021-20111004	PB02-I-C-BCR-E-012-20111005	PB02-F-C-HHC-E-009-20111001	PB02-F-C-HHC-E-010-20111001
Sample Date	10/4/2011	10/4/2011	10/4/2011	10/4/2011	10/1/2011	10/1/2011
Sample Type	N	N	N	N	N	N
X Coordinate	3201374.07	3201324.85	3201324.85	3201402.50	3201655.32	3201655.32
Y Coordinate	13834216.42	13833935.26	13833935.26	13833914.52	13833022.20	13833022.20
Scientific Name	Callinectes sapidus	Ariopsis felis	Ariopsis felis	Callinectes sapidus	Ariopsis felis	Ariopsis felis
Common Name	Blue crab	Hardhead catfish	Hardhead catfish	Blue crab	Hardhead catfish	Hardhead catfish
PCB Congeners (µg/kg)						
Total PCB Congener (U = 1/2)	**102.12319 J**	**361.5984 J**	**1471.84883 J**	**107.287 J**	**1853.65397 J**	**863.18713 J**
PCB Congeners (ng/kg)						
Total PCB Congener TEQ 2005 (Mammal) (U = 1/2)*	**3**	**5.29 J**	**26.9 J**	**3.737**	**49.7 J**	**7.23**

Appendix A-7
Results for Edible Tissue Samples

Station Code	PB047.2_B	PB049_B	PB049_B	PB053_C	PB056.3	PB056_B
Sample ID	PB02-F-C-HHC-E-011-20111001	PB02-F-C-HHC-E-013-20111001	PB02-I-C-BCR-E-009-20111002	PB02-I-C-BCR-E-006-20110930	PB03-F-C-HHC-E-003-20111004	PB02-I-C-BCR-E-004-20110930
Sample Date	10/1/2011	10/1/2011	10/2/2011	9/30/2011	10/4/2011	9/30/2011
Sample Type	N	N	N	N	N	N
X Coordinate	3201655.32	3201416.26	3201416.26	3201432.35	3201532.30	3201453.82
Y Coordinate	13833022.20	13832720.82	13832720.82	13832412.67	13832199.50	13832166.10
Scientific Name	Ariopsis felis	Ariopsis felis	Callinectes sapidus	Callinectes sapidus	Ariopsis felis	Callinectes sapidus
Common Name	Hardhead catfish	Hardhead catfish	Blue crab	Blue crab	Hardhead catfish	Blue crab
PCB Congeners (µg/kg)						
Total PCB Congener (U = 1/2)	5362.20851 J	985.00802 J	90.84184 J	66.76642 J	706.12259 J	123.028 J
PCB Congeners (ng/kg)						
Total PCB Congener TEQ 2005 (Mammal) (U = 1/2)*	85.6	15.3 J	2.3	1.99	12.9 J	3.16 J

Appendix A-7
Results for Edible Tissue Samples

Station Code	PB057.6	PB057_C	PB059.2_B	PB063.1_B	PB064_B	PB074_B
Sample ID	PB03-F-C-HHC-E-001-20111002	PB03-F-C-HHC-E-002-20111003	PB03-I-C-BCR-E-003-20110930	PB03-I-C-BCR-E-005-20111001	PB03-I-C-BCR-E-007-20111002	PB03-I-C-BCR-E-001-20110930
Sample Date	10/2/2011	10/3/2011	9/30/2011	10/1/2011	10/2/2011	9/30/2011
Sample Type	N	N	N	N	N	N
X Coordinate	3201552.02	3201624.77	3201656.50	3201471.90	3201628.19	3200805.71
Y Coordinate	13832110.15	13832089.74	13831811.55	13831485.98	13831233.59	13830418.11
Scientific Name	Ariopsis felis	Ariopsis felis	Callinectes sapidus	Callinectes sapidus	Callinectes sapidus	Callinectes sapidus
Common Name	Hardhead catfish	Hardhead catfish	Blue crab	Blue crab	Blue crab	Blue crab
PCB Congeners (µg/kg)						
Total PCB Congener (U = 1/2)	**2063.80724 J**	**1111.34443 J**	**151.90937 J**	**192.39999 J**	**91.95928 J**	**50.30239 J**
PCB Congeners (ng/kg)						
Total PCB Congener TEQ 2005 (Mammal) (U = 1/2)*	**34.3 J**	**20.2**	**5.24 J**	**5.24 J**	**2.77 J**	**0.34**

Appendix A-7
Results for Edible Tissue Samples

Notes:
*Result multipled by Toxicity Equivalent Factor (TEF).
Bold = Detected result
J = Estimated value
N = Normal Field Sample
U = Compound analyzed, but not detected above detection limit
UJ = Compound analyzed, but not detected above estimated detection limit
µg/kg = micrograms per kilogram
ng/kg = nanograms per kilogram
Totals are calculated as the sum of all detected results and half of the detection limit of undetected results (U=1/2).

Appendix A-8
Results for Whole Body Tissue Samples

Station Code	PB002.1	PB003.1	PB005.1	PB006.1	PB008.2
Sample ID	PB01-I-A-BCR-W-001-COMP-201106	PB01-F-A-STM-W-006-20110618	PB01-I-A-BCR-W-002-COMP-201106	PB01-I-B-WHS-W-002-COMP-201106	PB01-I-B-WHS-W-001-COMP-201106
Sample Date	6/20/2011	6/18/2011	6/20/2011	6/20/2011	6/19/2011
Sample Type	N	N	N	N	N
X Coordinate	3202691	3202445.49	3202312	3202026.63	3202032
Y Coordinate	13836499	13836263.53	13836201	13836356.8	13836072
Scientific Name	Callinectes sapidus	Mugil cephalus	Callinectes sapidus	Penaeus setiferus	Penaeus setiferus
Common Name	Blue crab	Striped mullet	Blue crab	White shrimp	White shrimp
PCB Congeners (µg/kg)					
Total PCB Congener (U = 1/2)	**228.67653 J**	**596.17603 J**	**324.01732 J**	**918.63783 J**	**547.93937 J**
PCB Congeners (ng/kg)					
Total PCB Congener TEQ 1998 (Avian) (U = 1/2)*	**97.57 J**	**103.7 J**	**147.29**	**312.2 J**	**177.4**
Total PCB Congener TEQ 2005 (Mammal) (U = 1/2)*	**8.35 J**	**5.7 J**	**11.28**	**16.7 J**	**9.3**

Appendix A-8
Results for Whole Body Tissue Samples

Station Code	PB010	PB010.1	PB010.3	PB013.1_A	PB013.3
Sample ID	PB01-F-A-GM-W-008-20110618	PB01-I-A-WHS-W-001-COMP-201106	PB01-I-A-BCR-W-003-COMP-201106	PB01-I-A-BCR-W-010-COMP-201106	PB01-F-A-GKF-W-004-COMP-201106
Sample Date	6/18/2011	6/20/2011	6/19/2011	6/22/2011	6/21/2011
Sample Type	N	N	N	N	N
X Coordinate	3201710.87	3201704.8	3201743	3201306.47	3201433.88
Y Coordinate	13836029.16	13836071.32	13836152	13836191.23	13836075.12
Scientific Name	Brevoortia patronus	Penaeus setiferus	Callinectes sapidus	Callinectes sapidus	Fundulus grandis
Common Name	Gulf menhaden	White shrimp	Blue crab	Blue crab	Gulf killifish
PCB Congeners (µg/kg)					
Total PCB Congener (U = 1/2)	**1259.03088 J**	**837.22995 J**	**680.86441 J**	**457.64751 J**	**3781.23762 J**
PCB Congeners (ng/kg)					
Total PCB Congener TEQ 1998 (Avian) (U = 1/2)*	**197.09 J**	**277.3 J**	**281.21**	**260.92**	**602.3**
Total PCB Congener TEQ 2005 (Mammal) (U = 1/2)*	**12.88 J**	**18.1 J**	**23.5**	**14.97**	**61**

Appendix A-8
Results for Whole Body Tissue Samples

Station Code	PB013.3	PB015.1	PB015.2	PB015_A	PB015_A
Sample ID	PB01-F-A-STM-W-003-20110616	PB01-F-A-GKF-W-002-COMP-201106	PB01-I-A-BCR-W-004-COMP-201106	PB01-F-A-GKF-W-001-COMP-201106	PB01-I-A-BCR-W-006-COMP-201106
Sample Date	6/15/2011	6/15/2011	6/16/2011	6/25/2011	6/22/2011
Sample Type	N	N	N	N	N
X Coordinate	3201433.88	3201175	3201180	3201168.73	3201168.73
Y Coordinate	13836075.12	13836251	13836183	13836254.66	13836254.66
Scientific Name	Mugil cephalus	Fundulus grandis	Callinectes sapidus	Fundulus grandis	Callinectes sapidus
Common Name	Striped mullet	Gulf killifish	Blue crab	Gulf killifish	Blue crab
PCB Congeners (µg/kg)					
Total PCB Congener (U = 1/2)	1793.31868 J	3359.20387 J	763.87414 J	5163.1206 J	560.77599 J
PCB Congeners (ng/kg)					
Total PCB Congener TEQ 1998 (Avian) (U = 1/2)*	234.7 J	526.2 J	362	728.24894 J	294.5
Total PCB Congener TEQ 2005 (Mammal) (U = 1/2)*	16.4 J	45.4 J	25.5	88.92282 J	19.4

Appendix A-8
Results for Whole Body Tissue Samples

Station Code	PB015_A	PB015_A	PB015_A	PB016.2	PB019.1
Sample ID	PB01-I-A-BCR-W-007-COMP-201106	PB01-I-A-BCR-W-009-COMP-201106	PB01-I-B-BRS-W-001-COMP-201106	PB01-F-A-GKF-W-003-COMP-201106	PB01-F-A-SAS-W-005-20110622
Sample Date	6/22/2011	6/22/2011	6/20/2011	6/15/2011	6/22/2011
Sample Type	N	N	N	N	N
X Coordinate	3201168.73	3201168.73	3201168.73	3201190	3201152.87
Y Coordinate	13836254.66	13836254.66	13836254.66	13836042	13835753.58
Scientific Name	Callinectes sapidus	Callinectes sapidus	Penaeus aztecus	Fundulus grandis	Cynoscion arenarius
Common Name	Blue crab	Blue crab	Brown shrimp	Gulf killifish	Sand seatrout
PCB Congeners (µg/kg)					
Total PCB Congener (U = 1/2)	487.9288 J	674.94424 J	1167.28808 J	1964.62179 J	1448.89245 J
PCB Congeners (ng/kg)					
Total PCB Congener TEQ 1998 (Avian) (U = 1/2)*	312.4 J	434.33 J	433.2 J	270.7	77.5 J
Total PCB Congener TEQ 2005 (Mammal) (U = 1/2)*	32.5 J	23.74 J	23.2 J	25.4	3.63 J

Appendix A-8
Results for Whole Body Tissue Samples

Station Code	PB019.1	PB019.1	PB019.1	PB019.1	PB019.1	PB019.1
Sample ID	PB01-I-B-BRS-W-012-20110621	PB01-I-B-BRS-W-014-20110621	PB01-I-B-BRS-W-015-20110621	PB01-I-B-BRS-W-019-20110621	PB01-I-B-BRS-W-022-20110622	PB01-I-B-BRS-W-023-20110622
Sample Date	6/21/2011	6/21/2011	6/21/2011	6/21/2011	6/22/2011	6/22/2011
Sample Type	N	N	N	N	N	N
X Coordinate	3201152.87	3201152.87	3201152.87	3201152.87	3201152.87	3201152.87
Y Coordinate	13835753.58	13835753.58	13835753.58	13835753.58	13835753.58	13835753.58
Scientific Name	Penaeus aztecus	Penaeus aztecus	Penaeus aztecus	Penaeus aztecus	Penaeus aztecus	Penaeus aztecus
Common Name	Brown shrimp	Brown shrimp	Brown shrimp	Brown shrimp	Brown shrimp	Brown shrimp
PCB Congeners (µg/kg)						
Total PCB Congener (U = 1/2)	**2092.1229 J**	**1730.5598 J**	**1552.6841 J**	**2192.3715 J**	**2031.98889 J**	**1964.85931 J**
PCB Congeners (ng/kg)						
Total PCB Congener TEQ 1998 (Avian) (U = 1/2)*	**586.73896 J**	**559.5 J**	**504.6 J**	**694.7385 J**	**567.57 J**	**544.7**
Total PCB Congener TEQ 2005 (Mammal) (U = 1/2)*	**20.15058 J**	**8.2 J**	**22.5 J**	**41.1819 J**	**30.43 J**	**31**

Appendix A-8
Results for Whole Body Tissue Samples

Station Code	PB019.2	PB019_A	PB019_A	PB024.1	PB024.1
Sample ID	PB01-I-A-OYS-W-001-COMP-201106	PB01-F-A-GKF-W-005-COMP-201106	PB01-I-A-BCR-W-008-COMP-201106	PB01-F-A-GM-W-001-20110615	PB01-F-A-GM-W-002-20110615
Sample Date	6/28/2011	6/21/2011	6/23/2011	6/15/2011	6/15/2011
Sample Type	N	N	N	N	N
X Coordinate	3201194.8	3201314.96	3201314.96	3201090.96	3201090.96
Y Coordinate	13835735.1	13835750.59	13835750.59	13835160.37	13835160.37
Scientific Name	Crassostrea virginica	Fundulus grandis	Callinectes sapidus	Brevoortia patronus	Brevoortia patronus
Common Name	Oyster	Gulf killifish	Blue crab	Gulf menhaden	Gulf menhaden
PCB Congeners (µg/kg)					
Total PCB Congener (U = 1/2)	1429.43904 J	3824.70099 J	695.21928 J	1896.42209 J	1735.87221 J
PCB Congeners (ng/kg)					
Total PCB Congener TEQ 1998 (Avian) (U = 1/2)*	361.21	577.2 J	331.4 J	267.5	241.5 J
Total PCB Congener TEQ 2005 (Mammal) (U = 1/2)*	20.74	58.6 J	20.0 J	19.6	16.6 J

Appendix A-8
Results for Whole Body Tissue Samples

Station Code	PB024.4	PB025_A	PB026.1	PB032_A	PB037.2	PB037.4
Sample ID	PB01-I-A-BCR-W-005-COMP-201106	PB01-F-A-GM-W-004-20110615	PB01-F-A-STM-W-002-20110616	PB02-F-A-PNF-W-009-20110617	PB02-F-A-STM-W-006-20110616	PB02-I-B-BCR-W-001-COMP-201106
Sample Date	6/20/2011	6/15/2011	6/15/2011	6/17/2011	6/16/2011	6/17/2011
Sample Type	N	N	N	N	N	N
X Coordinate	3201319	3201214.42	3201153.65	3201407.03	3201346.97	3201504
Y Coordinate	13835188	13835154.42	13835079.21	13834542.25	13834038.02	13833530
Scientific Name	Callinectes sapidus	Brevoortia patronus	Mugil cephalus	Lagodon rhomboides	Mugil cephalus	Callinectes sapidus
Common Name	Blue crab	Gulf menhaden	Striped mullet	Pinfish	Striped mullet	Blue crab
PCB Congeners (µg/kg)						
Total PCB Congener (U = 1/2)	**864.80731 J**	**2862.77347 J**	**2310.20497 J**	**2113.55066 J**	**3115.9855 J**	**935.99524 J**
PCB Congeners (ng/kg)						
Total PCB Congener TEQ 1998 (Avian) (U = 1/2)*	**307.6 J**	**426.7**	**321.5**	**89.6 J**	**453.3**	**509.3 J**
Total PCB Congener TEQ 2005 (Mammal) (U = 1/2)*	**19.0 J**	**31.6**	**24.8**	**24.0 J**	**26.7**	**43.1 J**

Appendix A-8
Results for Whole Body Tissue Samples

Station Code	PB037.5	PB037.6	PB037_A	PB047.1_A	PB047.3
Sample ID	PB02-I-B-BRS-W-001-COMP-201106	PB02-I-A-BCR-W-002-COMP-201106	PB02-I-A-BCR-W-004-COMP-201106	PB02-F-A-PNF-W-002-20110615	PB02-I-A-BCR-W-001-COMP-201106
Sample Date	6/17/2011	6/16/2011	6/19/2011	6/15/2011	6/19/2011
Sample Type	N	N	N	N	N
X Coordinate	3201380	3201402	3201325.97	3201461.79	3201645
Y Coordinate	13834151	13833775	13833885.45	13833007.68	13832925
Scientific Name	Penaeus aztecus	Callinectes sapidus	Callinectes sapidus	Lagodon rhomboides	Callinectes sapidus
Common Name	Brown shrimp	Blue crab	Blue crab	Pinfish	Blue crab
PCB Congeners (µg/kg)					
Total PCB Congener (U = 1/2)	**996.65252 J**	**626.86472 J**	**1264.0983 J**	**3972.325 J**	**825.40509 J**
PCB Congeners (ng/kg)					
Total PCB Congener TEQ 1998 (Avian) (U = 1/2)*	**369.86 J**	**340.8**	**703.52**	**145**	**469.1**
Total PCB Congener TEQ 2005 (Mammal) (U = 1/2)*	**22.01 J**	**24.8**	**49.2**	**51.4**	**31.7**

Appendix A-8
Results for Whole Body Tissue Samples

Station Code	PB048.3	PB048.3	PB048.3	PB049_A	PB049_A	PB052.1
Sample ID	PB02-F-A-GM-W-001-20110616	PB02-F-A-GM-W-002-20110616	PB02-F-A-STM-W-001-20110616	PB02-F-A-GKF-W-001-COMP-201106	PB02-I-A-BCR-W-003-COMP-201106	PB02-F-A-SAS-W-002-20110616
Sample Date	6/16/2011	6/16/2011	6/16/2011	6/15/2011	6/22/2011	6/16/2011
Sample Type	N	N	N	N	N	N
X Coordinate	3201519.15	3201519.15	3201519.15	3201468.39	3201468.39	3201515.24
Y Coordinate	13832869.89	13832869.89	13832869.89	13832722.8	13832722.8	13832564.31
Scientific Name	Brevoortia patronus	Brevoortia patronus	Mugil cephalus	Fundulus grandis	Callinectes sapidus	Cynoscion arenarius
Common Name	Gulf menhaden	Gulf menhaden	Striped mullet	Gulf killifish	Blue crab	Sand seatrout
PCB Congeners (µg/kg)						
Total PCB Congener (U = 1/2)	**2424.48575 J**	**2275.85828 J**	**2745.07556 J**	**5144.33174 J**	**520.31625 J**	**2511.9561 J**
PCB Congeners (ng/kg)						
Total PCB Congener TEQ 1998 (Avian) (U = 1/2)*	**476.1**	**445.2**	**433.9**	**771.8 J**	**285.97**	**188.1 J**
Total PCB Congener TEQ 2005 (Mammal) (U = 1/2)*	**39.2**	**35**	**28.3**	**137.1 J**	**16.86**	**25.9 J**

Appendix A-8
Results for Whole Body Tissue Samples

Station Code	PB052.1	PB053.2	PB053.2
Sample ID	PB02-F-A-STM-W-003-20110616	PB02-F-A-GKF-W-025-20110621	PB02-F-A-GKF-W-029-20110622
Sample Date	6/16/2011	6/21/2011	6/22/2011
Sample Type	N	N	N
X Coordinate	3201515.24	3201266.16	3201266.16
Y Coordinate	13832564.31	13832433.69	13832433.69
Scientific Name	Mugil cephalus	Fundulus grandis	Fundulus grandis
Common Name	Striped mullet	Gulf killifish	Gulf killifish
PCB Congeners (µg/kg)			
Total PCB Congener (U = 1/2)	4538.5708 J	8847.99531 J	7110.91726 J
PCB Congeners (ng/kg)			
Total PCB Congener TEQ 1998 (Avian) (U = 1/2)*	789.3	1152.5 J	987.0 J
Total PCB Congener TEQ 2005 (Mammal) (U = 1/2)*	51.5	115.7 J	97.5 J

Station Code	PB053_B	PB056_A	PB056_A
Sample ID	PB02-F-A-GKF-W-013-20110618	PB02-F-A-GKF-W-010-20110618	PB02-F-A-GKF-W-011-20110618
Sample Date	6/18/2011	6/18/2011	6/18/2011
Sample Type	N	N	N
X Coordinate	3201390.48	3201420.22	3201420.22
Y Coordinate	13832440.54	13832183.54	13832183.54
Scientific Name	Fundulus grandis	Fundulus grandis	Fundulus grandis
Common Name	Gulf killifish	Gulf killifish	Gulf killifish
PCB Congeners (µg/kg)			
Total PCB Congener (U = 1/2)	6767.23534 J	5242.30661 J	5593.7636 J
PCB Congeners (ng/kg)			
Total PCB Congener TEQ 1998 (Avian) (U = 1/2)*	1091.86215 J	943.33 J	865.8 J
Total PCB Congener TEQ 2005 (Mammal) (U = 1/2)*	111.43945 J	96.35 J	85.6 J

Appendix A-8
Results for Whole Body Tissue Samples

Station Code	PB057.2	PB057.2	PB057.2	PB057.2	PB057_B	PB057_B
Sample ID	PB03-F-A-GM-W-001-20110617	PB03-F-A-STM-W-001-20110617	PB03-F-A-STM-W-001-COMP-201106	PB03-F-A-STM-W-002-20110617	PB03-F-A-GKF-W-001-20110615	PB03-F-A-GKF-W-006-20110617
Sample Date	6/17/2011	6/17/2011	6/17/2011	6/17/2011	6/15/2011	6/17/2011
Sample Type	N	N	N	N	N	N
X Coordinate	3201603.32	3201603.32	3201603.32	3201603.32	3201644.06	3201644.06
Y Coordinate	13832054.52	13832054.52	13832054.52	13832054.52	13832071.63	13832071.63
Scientific Name	Brevoortia patronus	Mugil cephalus	Mugil cephalus	Mugil cephalus	Fundulus grandis	Fundulus grandis
Common Name	Gulf menhaden	Striped mullet	Striped mullet	Striped mullet	Gulf killifish	Gulf killifish
PCB Congeners (µg/kg)						
Total PCB Congener (U = 1/2)	2890.24146 J	1504.83803 J	1735.51448 J	1870.51601 J	4600.51158 J	7061.45581 J
PCB Congeners (ng/kg)						
Total PCB Congener TEQ 1998 (Avian) (U = 1/2)*	440.06 J	273.09 J	324.86	267.9 J	826.9	959.8
Total PCB Congener TEQ 2005 (Mammal) (U = 1/2)*	33.08 J	19.27 J	4.26	17.7 J	80.2	87.5

Appendix A-8
Results for Whole Body Tissue Samples

Station Code	PB057_B	PB058.1	PB058.1	PB058.1	PB059.1_A	PB059.1_A
Sample ID	PB03-F-A-PNF-W-001-COMP-201106	PB03-F-A-GM-W-003-20110618	PB03-F-A-GM-W-004-20110618	PB03-F-A-GM-W-005-20110618	PB03-F-A-GKF-W-003-20110615	PB03-I-A-BCR-W-003-COMP-201106
Sample Date	6/15/2011	6/18/2011	6/18/2011	6/18/2011	6/15/2011	6/19/2011
Sample Type	N	N	N	N	N	N
X Coordinate	3201644.06	3201682.3	3201682.3	3201682.3	3201501.32	3201501.32
Y Coordinate	13832071.63	13832011.93	13832011.93	13832011.93	13831828.71	13831828.71
Scientific Name	Lagodon rhomboides	Brevoortia patronus	Brevoortia patronus	Brevoortia patronus	Fundulus grandis	Callinectes sapidus
Common Name	Pinfish	Gulf menhaden	Gulf menhaden	Gulf menhaden	Gulf killifish	Blue crab
PCB Congeners (µg/kg)						
Total PCB Congener (U = 1/2)	2206.62904 J	3070.34771 J	4005.38696 J	4003.44203 J	6501.4046 J	623.70212 J
PCB Congeners (ng/kg)						
Total PCB Congener TEQ 1998 (Avian) (U = 1/2)*	102.59	497.01 J	714.3	789.2 J	982.9	370.56
Total PCB Congener TEQ 2005 (Mammal) (U = 1/2)*	30.55	31.62 J	45.7	46.6 J	84.4	37.21

Appendix A-8
Results for Whole Body Tissue Samples

Station Code	PB059.3	PB059.4	PB059.5	PB063.1_A	PB063.1_A	PB063.2_A
Sample ID	PB03-I-B-BCR-W-002-20110627	PB03-I-B-BCR-W-003-20110628	PB03-I-A-BCR-W-001-COMP-201106	PB03-F-A-GKF-W-009-20110617	PB03-F-A-GKF-W-010-20110617	PB03-F-A-GKF-W-005-20110615
Sample Date	6/26/2011	6/27/2011	6/27/2011	6/17/2011	6/17/2011	6/15/2011
Sample Type	N	N	N	N	N	N
X Coordinate	3201714.16	3201714.16	3201714	3201509.99	3201509.99	3201561.28
Y Coordinate	13831964.63	13831964.63	13831965	13831505.57	13831505.57	13831519.55
Scientific Name	Callinectes sapidus	Callinectes sapidus	Callinectes sapidus	Fundulus grandis	Fundulus grandis	Fundulus grandis
Common Name	Blue crab	Blue crab	Blue crab	Gulf killifish	Gulf killifish	Gulf killifish
PCB Congeners (µg/kg)						
Total PCB Congener (U = 1/2)	**752.90059 J**	**722.04363 J**	**695.65724 J**	**4685.39063 J**	**6000.67773 J**	**5938.89019 J**
PCB Congeners (ng/kg)						
Total PCB Congener TEQ 1998 (Avian) (U = 1/2)*	**485.08**	**433.73**	**511.7**	**740.0 J**	**876.0 J**	**792.8**
Total PCB Congener TEQ 2005 (Mammal) (U = 1/2)*	**32.85**	**30.79**	**30.16**	**15.6 J**	**80.9 J**	**81.6**

Appendix A-8
Results for Whole Body Tissue Samples

Station Code	PB063.2_A	PB069_A	PB069_A	PB069_A	PB084.1	PB084.1
Sample ID	PB03-F-A-GKF-W-013-20110617	PB03-F-A-GKF-W-002-20110615	PB03-F-A-GKF-W-007-20110617	PB03-I-A-BCR-W-002-COMP-201106	PB04-F-A-GKF-W-005-20110627	PB04-F-A-GKF-W-013-20110627
Sample Date	6/17/2011	6/15/2011	6/17/2011	6/19/2011	6/27/2011	6/27/2011
Sample Type	N	N	N	N	N	N
X Coordinate	3201561.28	3201132.36	3201132.36	3201132.36	3200727.85	3200727.85
Y Coordinate	13831519.55	13830993.22	13830993.22	13830993.22	13829784.47	13829784.47
Scientific Name	Fundulus grandis	Fundulus grandis	Fundulus grandis	Callinectes sapidus	Fundulus grandis	Fundulus grandis
Common Name	Gulf killifish	Gulf killifish	Gulf killifish	Blue crab	Gulf killifish	Gulf killifish
PCB Congeners (µg/kg)						
Total PCB Congener (U = 1/2)	4473.19716 J	7758.93212 J	5075.27769 J	1142.42963 J	2915.8164 J	4586.76227 J
PCB Congeners (ng/kg)						
Total PCB Congener TEQ 1998 (Avian) (U = 1/2)*	741.1 J	1172.78974 J	908.2 J	782.88	454.2 J	739
Total PCB Congener TEQ 2005 (Mammal) (U = 1/2)*	70.3 J	112.62322 J	89.4 J	44.49	38.2 J	62.3

Appendix A-8
Results for Whole Body Tissue Samples

Station Code	PB095.2	PB101_D	PB101_D	PB101_D	PB102
Sample ID	PB04-I-A-BCR-W-001-COMP-201106	PB04-F-A-GKF-W-001-20110627	PB04-F-A-GKF-W-001-COMP-201106	PB04-F-A-GKF-W-009-20110627	PB04-F-A-PNF-W-001-COMP-201106
Sample Date	6/29/2011	6/27/2011	6/27/2011	6/27/2011	6/27/2011
Sample Type	N	N	N	N	N
X Coordinate	3200882	3201317.36	3201317.36	3201317.36	3201302.69
Y Coordinate	13829528	13828141.83	13828141.83	13828141.83	13828160.48
Scientific Name	Callinectes sapidus	Fundulus grandis	Fundulus grandis	Fundulus grandis	Lagodon rhomboides
Common Name	Blue crab	Gulf killifish	Gulf killifish	Gulf killifish	Pinfish
PCB Congeners (µg/kg)					
Total PCB Congener (U = 1/2)	361.36424 J	4123.00904 J	5547.2805 J	4322.1767 J	4333.6326 J
PCB Congeners (ng/kg)					
Total PCB Congener TEQ 1998 (Avian) (U = 1/2)*	231	623.1 J	837.3	694.7	147.6 J
Total PCB Congener TEQ 2005 (Mammal) (U = 1/2)*	14.5	64.8 J	75.3	69.4	39.0 J

Appendix A-8
Results for Whole Body Tissue Samples

Notes:
*Result multipled by Toxicity Equivalent Factor (TEF).
Bold = Detected result
J = Estimated value
N = Normal Field Sample
U = Compound analyzed, but not detected above detection limit
µg/kg = micrograms per kilogram
ng/kg = nanograms per kilogram
Totals are calculated as the sum of all detected results and half of the **detection limit** of undetected results (U=1/2).